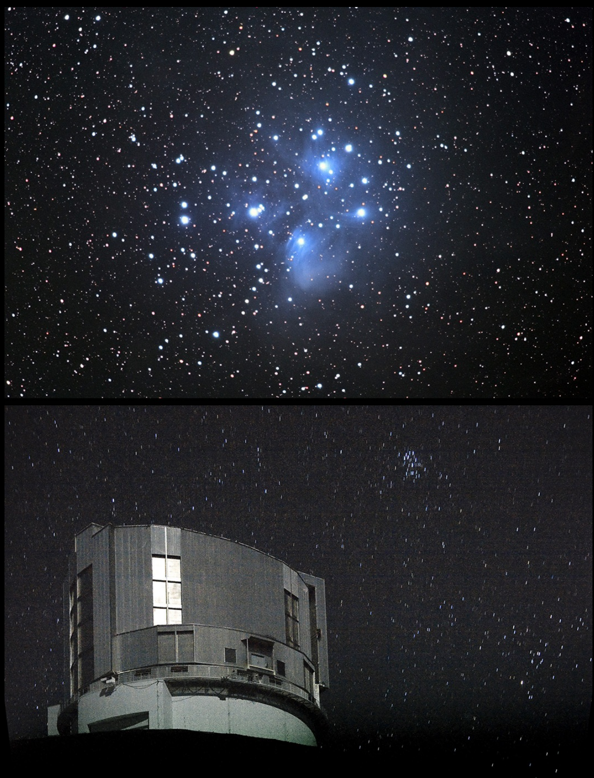
Makali‘i in Hawai‘i

Twenty Years of the Subaru Telescope Project
A Challenge to Reach the Edge of the Universe

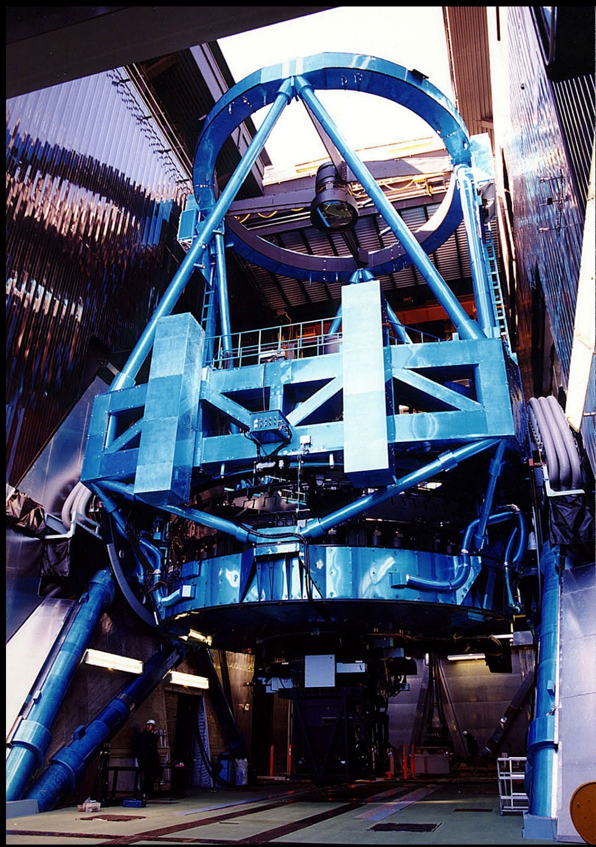
Keiichi Kodaira

Translated by
Kyoji Nariai

Cooperated
Hayakawa Publishing Corporation



Upper panel : Star-cluster Subaru = Pleiades = Makali'i. ©NAOJ
Lower panel : Enclosure of Subaru Telescope (lower left) and the star cluster Subaru (upper right). ©NAOJ



Subaru Telescope in the enclosure. ©NAOJ

The word Makali'i in the title of this English version is the Hawaiian word for the star cluster Pleiades, which ancient Hawaiians used as position and time indicator in the sky for their navigation over the Pacific Ocean with their outrigger-canoes.

The original meaning of Makali'i is Small Eyes. Hawaiians came from Makali'i according to a legend. In Japan, this beautiful conspicuous star cluster Pleiades has been called Subaru since the age of Yamato period, as was cited in the Makura-no-Sohshi by Sei Shonagon (Beautiful is) in Spring the Dawn, among stars Subaru.

The original meaning of Subaru is Gathering. The Japanese National Large Telescope (JNLT) was named Subaru. The Big telescopes gathering in Hawaii are yet Small Eyes seen from the universe.

The original Japanese version of this book Uchuu no Hatemade contained no explanatory photographs in the main text. Taking advantage of the new style of publication e-book, many pictures were added in this e-book, Makali'i in Hawai'i. We hope that readers enjoy them as well as the translated materials.

Photograph：Kiso Observatory (Institute of Astronomy, School of Science, The University of Tokyo) / NASA / Subaru Telescope, NAOJ / Okayama Astrophysical Observatory, NAOJ / Nobeyama Radio Observatory, NAOJ / Ishigakijima Astrophysical Observatory, NAOJ / Mitaka Library, NAOJ / Public Relations Center Publications Office, NAOJ / Keiichi Kodaira

Compilation and Production

Publications Office

Public Relations Center
National Astronomical Observatory of Japan（NAOJ）
National Institutes of Natural Sciences（NINS）

2-21-1 Osawa, Mitaka-shi, Tokyo 181-8588, Japan
TEL: +81-422-34-3958
FAX: +81-422-34-3952
http://prc.nao.ac.jp/publication/

ISBN978-4-908895-01-2

[Published] Keiichi Kodaira/Kyoji Nariai: 2016, NAOJ-Books : Makali'i in Hawai'i.

Index

Preface to the English Version

The word Makali'i used in the title of this book is the Hawaiian name of the star cluster Pleiades from which the first Hawaiian people came to earth according to legend. In Japan, we call it as Subaru.

Translator Kyoji Nariai & his wife Kyo Nariai.

Keiichi Kodaira, the author of the book, and I, the translator, studied astronomy in the University of Tokyo in late 1950s. At that time, one of the frontier of astronomy in the world was stellar astrophysics, and Japan was trying to reach the top level with the newly built 188 cm telescope at Okayama. Both of us chose spectral analysis of peculiar stars for their start of professional career. At that time, the telescope at Okayama was the largest in Asia and was ranked as the sixth largest in the world. The 5 m telescope of Mt. Palomar, 3 m telescope of the Lick Observatory, 2.5 m telescope of Mt. Wilson were the top three large telescopes.

Although we enjoyed being one of the front runners in the world of astronomy for a few years, we learned in 1970s that many 3 m class telescopes were built at good astronomical sites and were enlarging the frontiers of astronomy, specially in the astronomy of galaxies and the cosmology, which Kodaira was interested in from the time he became an astronomer.

Japanese astronomers were anxious at the situations they were standing. They wanted to work at the top-level of astronomy, but without a big telescope, ... Early in the 1980s, after big debates in the Astronomical Society of Japan, it was agreed that a large telescope project starts as the Japan National Large Telescope project with a large telescope at the best astronomical site with its aim.

In the Tokyo Astronomical Observatory of the University of Tokyo, a group was formed with Prof. Kodaira as its leader. The size of the mirror was 7.5 m at the start of the project. It was changed to 8.2 m as the project proceeded. The site was decided to be Hawaii which was one of the three known superb astronomical sites on the earth. The name was changed from JNLT to Subaru Telescope. Tokyo Astronomical Observatory became National Astronomical Observatory of Japan. The Government fund was allocated on 1990, and the Subaru Telescope was completed on 1998.

Kodaira took record of many things during the Project and wrote a book in Japanese two years after the completion of Subaru Telescope. His aim was to leave the documentary of the project so that the younger generation can learn something from it when they use Subaru Telescope or when they start a new project of their own. Now, young Japanese astronomers in Japan are using Subaru Telescope and are working out world-class results, often in international collaboration.

Prof. Kodaira spent three years in Germany when young and married a German girl Freulein Uta Schumpp. Initially, I wanted to translate the book into English so that at least his wife could read the whole story of this large telescope. I also thought that this book could be useful for many scientists in advancing countries who are trying to promote new big science projects of their countries.

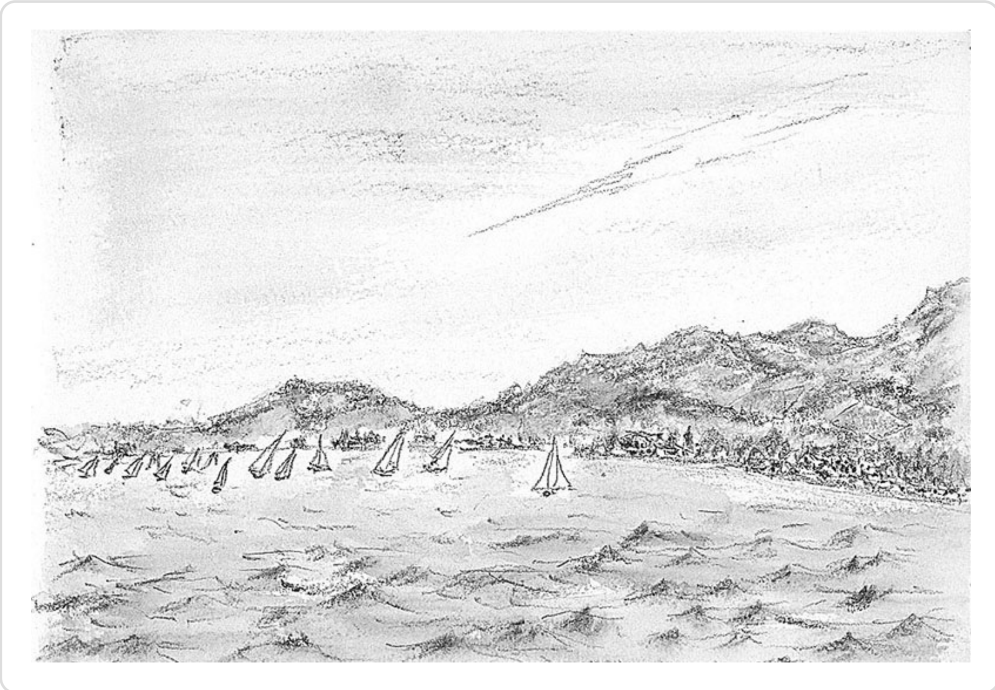
My sincere thanks are due to Prof. Chris Packham of the University of Texas who read the book thoroughly before publication and kindly made correction of English terms wherever necessary.

Kyoji Nariai
Mitaka, Tokyo, Japan
March, 2016

[Published] **Keiichi Kodaira/Kyoji Nariai**: **2016**, NAOJ-Books : Makali'i in Hawai'i.

Chapter 1

Dream for a Large Telescope



1.1

I was allocated three nights of observation time in June, 1980, for the four-meter telescope of Cerro Tololo Inter-American Observatory on the Andes Plateau in Chile, South America. Since I was going to make a long trip to Chile, I asked for an additional observation time of about two weeks for the 1.5 meter telescope and the 60-centimeter telescope. Chile is a long and narrow country. It has a national highway that runs north and south within its borders. The northern region of Chile is a very dry desert area. The Andes Plateau is 6,000 to 9,000 feet above the sea level. On the side where the Pacific Ocean meets the plateau, it is cut by a cliff, and offers very good conditions for astronomical observations. The air is dry and the wind is laminar.

On the peak of Cerro Tololo, there are five telescope domes. A few more domes lie several hundred meters away from them. A dormitory, restaurant, and machine shop are hidden by a small hill. There are Chilean style flats without much adornment. The inner walls of the dormitory are made of wood. Although the dorm has a balcony, it doesn't tempt me to sunbathe because the ultra-violet rays are too strong. Surrounding the buildings are rock hills. Small trees that were planted by people are growing feebly because of lack of water. Water is entirely supplied by sprinklers. Cactus and moss also thrive in the area. To my surprise, I found a ladybug. I also spotted a small lizard. The humidity sometimes reached a low of five percent. While shaving my face, my skin made a crunching noise. I decided not to shave so that I can avoid getting hurt. After two weeks, I got a fine beard. At first, when I arrived here, I felt a little uneasy because all the people working here had beards or moustaches.

"Now, you have mustache, too!"

the Mexican chef teases me. He comes out of the building to feed the condors with the leftover foods. One of the condors that flew elegantly above the Andes Mountains, landed slowly on the hand of the chef. Today's leftover for the condors is mutton. At the restaurant, mutton is always on the dinner menu. Yesterday, it was mutton. Today, too. The chef tries to soften it with a wooden bar before cooking, but it still is stiff. Leftovers come from the astronomers. The engineers working here are used to the stiff mutton.

The mountain scenery at dusk in the Andes is gorgeous. The Andes Plateau arose from a continental drift at the bottom of the Pacific Basin. It is famous for the fossils found at the bottom of the sea and for its rich ores of potassium nitrate, silver, etc. When the setting sun illuminates light on the old strata, it shines brilliantly in colors of deep red, violet, deep blue, orange, green, yellow, etc. In the daytime, the desert is discolored. It is usually a world without motion or sound except when four wheel drive vehicles sometimes come up to the mountain and stir up dust. However, at twilight time everything is lively. When the shadows of mountains get dark colored, the sky is waiting for its time to go on stage. The red clouds at the sunset are beautiful, but they are unwelcome by astronomers. When there are no clouds, the deep blue-sky changes slightly orange for a short time, then transforms into dark blue. The stars begin to shine brilliantly. As the air is quiet, stars near the zenith almost do not twinkle. Just above me lies the Milky Way, dividing the night sky. It looks quite big and makes me think that I am sitting in the throne of the sky. The dark nebula ‘Coal Sac’ clearly cuts a part of the Milky Way. The center of our Galaxy, at the constellation Sagittarius, is high up in the sky, with the Southern Cross rivaling it. The southern sky is rich in bright stars. I felt the true meaning of ‘starlight.’ The center of Galaxy is thirty thousand light years away. The Large Magellanic Cloud is in the midst of the sky and appears like a faint hazy moon. It is one hundred and fifty thousand light years away.

The aim of this observation is to determine the chemical composition of the globular cluster observable from the Southern Hemisphere. Globular clusters are thought to be among the oldest celestial objects in our Galaxy. The contents of its heavy elements are less than those of the Sun. More than one hundred thousand stars gather together to make a globular shape, therefore it is difficult to make accurate spectral analyses for individual stars. Moreover, they are faint because of the large distance. So, analysis can be made only with a large telescope built at a site with good seeing conditions. These three nights are the nights allocated to me as the results of competition for use of the world’s first class telescope. I have to use my time wisely. So, I decided to use the sixty-centimeter telescope and the one and a half-meter telescope to measure the accurate positions, brightness, and colors of the stars to be studied in the cluster. This preparation makes the observation with the large telescope effective, and also helps in the spectral analysis that will be done later on.


Omega Centauri, a globular cluster. ©NAOJ

Usually, this kind of preparation should have been done back in my country, but I could not do otherwise because I was going to study stars in the southern sky.

Every night when I rotate the dome, direct the telescope to a star, and peek into the guiding telescope, my heart leaps with an expectation of 'What am I going to find tonight?' I am very careful when I observe a new star. Even if I am directing the telescope to one of my favorite stars, I check to make sure there is nothing peculiar with the star or with any of the nearby stars. This star is observed only once by human kind tonight. When I catch the star in the viewer of the guiding telescope, I check to make sure that I am not making any mistake in its position, brightness, and neighboring stars. Then I devote myself in watching the blue-white light point on the slit of the spectrograph. When the night is over, I go back to the dormitory, fall into bed, and sleep.

I came to Chile to make observations. But I had another reason why I came here. I wanted to experience a large telescope built at a good site, and to study the organization that supports its operations. I got up in the morning and went to the dome. I was taking notes as the engineering staff were checking the telescope and observational instruments. A large man with a hard hat came close and asked me.

"What are you doing?"

"I wish to study how the engineering staff work"

I replied.

" Are you an astronomer or an engineer?"

"I am an astronomer."

"If you are an astronomer, sleep well in the daytime and observe well at night."

"Is it forbidden to watch you working?"

"It's OK, but if you wish to stay here, you have to put a hard hat on."

I was allowed to watch them.

There is still a possibility that something can go wrong in spite of the thorough check in the daytime.

"Switching to the comparison light doesn't work,"

the observer says to the telescope operator.

"Did you push the button firmly? Let me do it. OK. It doesn't work."

The operator makes a telephone call. He is speaking with an engineer who is on the nightshift.

"Switching doesn't work. Yes, that lamp is on. No, it's off."

An engineer who is probably in charge of the computer system came up by car and started to check the switches. He made a telephone call and said,

"It should be one of the motors that is wrong. A mechanical engineer will come up."

Then, he went down. After a while a mechanical engineer came and fixed it. Several people were readily standing by at the summit during the night.

The base facility of the Cerro Tololo Inter-American Observatory is on the coast of La Serena, a city at the mountain skirt. In the lot, surrounded by fence, there are: a research building, a machine shop, residences, a kindergarten school, and tennis courts. I was told some one hundred and fifty people are living there. It takes eight hours by bus when traveling from Santiago, the capital of Chile, to La Serena. Traveling to the summit from La Serena takes three more hours. A little farther than the first mountain pass, there is a gate. Large special vehicles for the maintenance of the roads are there as well as a gasoline station. This is the gate that leads to the observatory.

On the Andes Plateau in northern Chile there are, besides this Cerro Tololo Inter-American Observatory which is run mainly by the U.S.A., Las Campanas Observatory run by the Carnegie Foundation of U.S.A. and European Southern Observatory (ESO) run by the association in Europe. Every one of them has world first class large telescopes. During my trip, I visited these observatories too. ESO in La Silla is the largest among them. It has more than a dozen telescopes on the mountain. Behind a hill, which is close by, is a large lodging facility comparable to a hotel. There are more than a hundred people staying on the mountain. A movie is shown for entertainment every weekend night. As the core of this group consists of Germany, France, and Italy, the foods are as good as foods served in three-star restaurants. There is an office in the city of La Serena at the foot of the mountain, but the main effort is centered on the mountain facility. In Santiago, there is a big office/lodging facility. This office also has its own airplane to commute to La Serena. The main office of ESO is in Garching, in the suburb of Munich, and is always crowded like the center of astronomy in Europe. Studies of telescopes and observational instruments are done there. The most recent technology is used in the developmental study. They work on the computer technology to control the instruments and software for the analysis of observed data. They also accumulate and control the final observational data. The data are sent to the researchers in all the Europe. Trips occur quite often between the mother countries and Chile. At the airport, they are treated as 'diplomats.' When I arrived at the airport of Santiago, the office staff of ESO who came to see me had a badge of 'ESO,' so there were no entry formalities before I got in the car. The mails posted at the summit are put in a special diplomat's bag, then carried to the main office in Munich. From there, they go out to their destinations.

When I got back to Santiago, after three weeks of study and observations, my face was covered with a beard. It was wintertime in Chile. Christmas cookies and tarts were lining up in the windows of confectioneries in Santiago. I went to a German restaurant by walking on a road covered with thin snow, and had a glass of beer. I thought while I was drinking the beer.

'Is it possible for us Japanese to build a large telescope in Chile?'

I got a little depressed thinking of how Japan lies far away.

'It is difficult to build a new telescope, even in Japan, which means it is almost impossible to build it abroad.'

After the beer, I climbed up a hill that commands the city. It was a little after noon. Smog filled the town, and I saw that there was a slum down below the hill. After getting back to the town, I went out to go to a movie theater. It was noisy outside the hotel. Soldiers with bayonets were standing guard at the street cross sections. For a moment, I was afraid of coup d'état, but it was not. The Chile soccer team won against Brazil. The whole town was noisy until dawn the next day.

My stubby beard didn't suit Tokyo. My wife and daughters suggested me to keep some of my beard as a memento. So, I decided to keep moustache.

At the end of this year, Voyager I, a planet surveyor, got close to Saturn.

1.2

At that time, the study of the Next Large Telescope Project was not going smoothly. Among the Japanese universities, only the University of Tokyo, the Kyoto University, and the Tohoku University had graduate courses in astronomy. Among them only the Tokyo Astronomical Observatory of the University of Tokyo had a telescope for observational study of stars. The Tokyo Astronomical Observatory had its main campus in Mitaka, Tokyo ever since when the University of Tokyo was the Imperial University of Tokyo. Due to the development of the surrounding area, the effect of artificial lights on the night sky became large. So, after the World War II, the new telescopes were built at mountain sites far from Tokyo at places like Saitama Prefecture, Nagano Prefecture, and Okayama Prefecture.

Of course other universities tried to get a telescope for research. But they did not succeed, and the Tokyo Astronomical Observatory remained to be the only center of the observational astronomy in Japan.

The Tokyo Astronomical Observatory, with a long tradition, celebrated its one-hundredth anniversary on November 1978. In the same year, the Tokyo Astronomical Observatory was admitted a fund for the construction of a Large Radio Telescope at Nobeyama. This was a desire long-time cherished by the Japanese astronomical researchers. The Astronomical Society of Japan was then going to materialize the request for the fund of the Next Large Optical Telescope. Professor

Yasumasa Yamashita, director of the Okayama Astrophysical Station of the Tokyo Astronomical Observatory, and Dr. Kyoji Nariai of the same observatory started its preparation. I was also a member of this preparation group although I did not belong to the observatory. I belonged to the Faculty of Science of the University of Tokyo. However, the project had problems from the start which could not be solved easily.

Various kinds of radiation come to the Earth from the universe. As the atmosphere protects the Earth, X-rays and ultraviolet rays are absorbed high above the atmosphere and do not reach the Earth's surface. The 'windows,' through which the atmosphere lets radiation from the universe pass, are the visible light window around 0.5 micrometer and radio wave window whose wavelength is around 1 centimeter. Corresponding to these two windows, we have optical telescopes and radio telescopes as the Earth-bound instruments to observe the sky. Radio telescopes are large parabolas with high efficiency. Observations in X-ray or ultraviolet light need a telescope elevated above the atmosphere in a balloon, rocket or satellite. Observations in other wavelengths are done the same way when atmospheric effects are to be avoided.

Optical telescopes, used for the research of stars, are reflecting telescopes that use mirrors, not lenses. The diameter of the tube of such a telescope is between two and four meters and its length is more than 10 meters. The construction cost, including the dome, ranges from a several to ten million dollars. Since the site is on the summit of a mountain and is far away from the living quarter, civil engineering work is necessary to prepare the site and make the roads.

European and American countries had already constructed four meter class telescopes at good sites like Chile and widened the frontier of the optical astronomy. The largest telescope in Japan, built in 1960, is a 188-centimeter telescope at the Okayama Astrophysical Station. At that time, it was the world's sixth largest telescope, but now it is ranked around the thirtieth. It was obvious that we needed more light to observe fainter objects. A four-meter class telescope was essential for research at the frontier of astronomy.

The Tokyo Astronomical Observatory was studying the Next Large Telescope Project with a target of a 3.5 meter telescope. But the plan did not have consensus in two points.

The first point was the selection of the telescope system. Should we choose either a classical design of a traditional thick and heavy mirror with equatorial mounting, or a challenging 'new technology telescope' which has a thin and light-weight mirror with computer-controlled alt-azimuth mounting? The second point was where to build this expensive telescope, in Japan where the climatic and atmospheric conditions are not favorable, or at the best site in the world. The first problem is related to the weakness of the Achilles tendon of the Japanese astronomy. Japanese astronomy started off being practical such as the making of the calendar or the determination of longitude and latitude. The situation has improved little by little, but we imported most of the modern instruments from abroad. We did not have an attitude to study the universe with our own instruments. In our observatory, we had only a small area that could be referred to as a laboratory. The machine shop was poor in its content. Therefore, we did not have a group of engineers among the researchers and staff in our observatory. The dominant idea was it is safe to build a telescope with established engineering.

To build a telescope abroad seemed to present more problems. It was difficult for an individual researcher to make a foreign trip for his research. About the travel expenses, there was no way to make a foreign trip except with the national fund. It was really difficult to get the travel fund from the Ministry of Education, Science, and Culture (MESC). Even if the fund is admitted, the language problem and the differences of systems may pose the next barriers. Therefore, it seemed very complicated, and the possibility of realizing it seemed to be infinitely close to zero.

"Thinking of our power, it is most appropriate to build a 3.5 meter telescope in Japan."

"No, let us build many two-meter telescopes to stimulate researches with originality. It costs quite a bit cheaper."

“The observatory of the University of Tokyo should not have a telescope again. Kyoto University or Tohoku University should have it.”

There were many opinions in the Astronomical Society of Japan, and each one had its reason. Since I was not a staff of the Tokyo Astronomical Observatory, I joined and listened to such discussions without a firm standpoint.

In the year 1979, when the Japanese astronomical world was still continuing the same discussions since several years, a symposium on the Space Telescope (ST) project was held at the Princeton Institute for Advanced Studies where Einstein continued his research after he moved to U.S.A. It was a project to launch an optical telescope above the atmosphere and to observe the universe without being obstructed by the Earth’s atmosphere. I was invited to this symposium since I was making an experiment of a stratosphere balloon based telescope. I was the only invitee from Japan. The four-meter diameter ST plan I heard at the symposium was really majestic. I was impressed by their sincere and brave attitude to use every bit of science and engineering and start developmental studies in order to observe the universe in detail. As I listened to the discussion at the symposium, I recalled the deep impression I had when I went to Germany fifteen years ago and the passion I felt at Mt.Wilson observatory ten years ago. During the discussion for Japan’s next large telescope with prospect still uncertain, the dream I had as a postgraduate youth and had almost forgotten came back to me.

1.3

I started to dream of becoming an astronomer when I was a fifth grader.

“Won’t you come to see the observatory?”

my teacher in charge of the class asked me. I answered with joy,

“Yes.”

The Motosumiyoshi Elementary School of the City of Kawasaki allowed me to join the tour to the observatory, which was arranged for the science teachers. The leader of the tour was Mr. Toshiyuki Minowa of the Nishi-Ikuta Elementary School. He was one of the founders of the Kawasaki Association of Astronomy. Because of this tour, I joined the Association upon entering middle school, and began to visit the offices of Mr. Koichiro Tomita and Mr. Shigeru Kaho in the Tokyo Astronomical Observatory.

I was fond of science ever since I was a kid. The planetarium, to which my father took me when I was a first grader, fascinated me. It was located in the Electric Building of Osaka. It was still open at the time when everything was regulated by the wartime policy. Soon my father went to the war and then returned home after the war. During his absence, the night sky was full of B29 bombers, flashes of Japanese searchlights, flashes of anti-aircraft guns, raining fire-bombs, and a burning city. So, I remember neither stars nor the moon. What I remember is the feeling of hunger during the evacuation just before and after the end of World War II. Upon my father's return, we moved to Tachikawa, Tokyo. The city was filled with the occupation army soldiers and girls clad with colorful dresses. With a few good friends of mine, I built a 'Tarzan hut' in a farmer's yard. We gathered there together after school and played. One of our favorite games was to measure the position and the shape of the moon that shines after the sunset.

"I found that the moon moves from the West to the East,"

I reported to my teacher. He looked doubtful of my findings and told me,

"Observe it once more carefully."

I measured the moon in the evenings at the same hour. Everyday I found the moon moved from the West to the East.

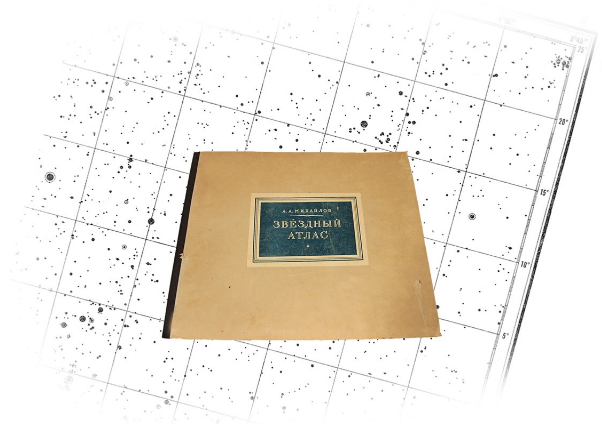
'Our teacher should come and look at it. We are right,'

we insisted. I did not realize that the moon and stars move together to the West in one evening.

We moved to Kawasaki. The new school and the new house did not have a large tree. Instead, there was a river and a pond. The favorite games that were played included catching crawfish, swimming, menko (card-game), and be-goma (top). At that time, the electricity service was poor. I do not remember what I was doing after supper which was usually served at a table lit by a battery light. I do not think I watched the starlit sky. I think I went to bed early after listening to children's program broadcast on the radio. TV did not exist at that time. I had a star atlas with Hevelius' Celestial Pictures which I don't remember where I got it. During the 'free hour' of the school, I would copy the animal gods of Greek mythology from the Hevelius' Pictures. Probably because of this, my teacher asked me if I would join the tour of the observatory.

Hevelius' Celestial Pictures

When I went to middle school, I did not continue copying the pictures of the animal gods. The senior members of the Association helped me to buy the star atlas of Mikhailov. A veteran observer, Mr. Tomita, helped me to make an eight-centimeter refractor. I went to Nippon Kogaku (Nikon) and got an achromatic doublet. I attended middle school at Aoyama Gakuin. I brought the refractor to the school and observed sunspots at the lunch hour with my good companies. I followed Mr. Tomita to help him when he observed meteors at Ikuta, Kawasaki. I may have been the only one who thought I had 'helped' him. Mr. Tomita took care of me although I may have been extra-trouble for him. The morning after the observation, I followed him to the Tokyo Astronomical Observatory. We ate



The star atlas of Mikhailov

breakfast near the Mitaka station of Chuo Line. Mr. Tomita may have used his coupon for food (gaishokuken) and shared the food with me at a small restaurant near the station. When arriving at the Observatory, we went out to the field and dug potatoes, cooked them in a pan, and filled our hungry stomachs.

In the campus of the Tokyo Astronomical Observatory, where there were big fields for vegetables, there were wooden houses for the staff. Mr. Kaho, known by his discovery of a comet, and Professor Hirose (who later, served as the seventh director of TAO) lived there. I learned later that Professor Hirose was the one who had the authority of the celestial mechanics. Mr. Kaho lived with his wife in a cozy wooden official residence. Mrs. Kaho was transcribing books into braille. His bookshelf was filled with old musty books which made me think,

'This is the life of an astronomer.'

He told me,

"Ask anything you wish."

I thought a little and asked,

"Why does the Foucault pendulum rotate?"

I asked that question because I had once seen one in the Science Museum in Ueno. I thought I had asked a fine question. But Mr. Kaho told me quietly,

"Find out the solution by yourself,"

and went away. I felt a little ashamed that I could not ask a better question.

I had a chemistry textbook of the high school under the old system, which I found in a secondhand bookstore. The cover was missing. I liked it because the book looked like a crib of alchemy. I changed the storeroom of my house into a laboratory, and did electrolysis of water, gummy membrane of Sulfur, colloid of iron hydrate, chlorine gas, and whatever I could do. I did not know the theory, but I liked it very much because of the shape and color changes. I stayed in the storeroom until my mother called for me. I started developing photographs in the closet, the only place in my house where I could shut out light. I also made wine, which turned out not to be very tasty although I tried many ways to improve it. I peeked into my handmade microscope and saw water fleas. I was fond of the miniature railway set. I made an electric fan, a steam engine, and a bread steamer that was popular at that time. My parents allowed me to play in that way.

As a first grader, I wrote in my picture diary,

'I wish to become a General of the Army.'

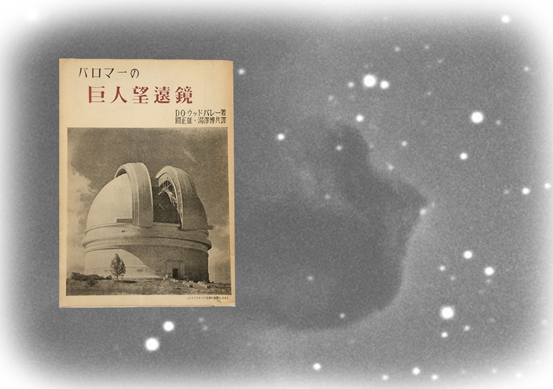
As a middle school boy, I was aiming to be an astronomer. Some people suggested me,

"Go to the Kyoto University if you wish to become an astronomer."

A friend of my father transmitted the suggestion to Professor Issei Yamamoto of the Kyoto University. Soon I received a letter from Professor Yamamoto saying,

'If you live in Tokyo, you can learn astronomy at the University of Tokyo.'

I found his 'Courses of the Cosmic Physics' in a secondhand bookseller after I entered high school and understood vaguely that Professor Yamamoto was a big figure in astronomy. I was told it was necessary to study in a public high school in order to enter the University of Tokyo. I challenged the mock entrance examination twice, then filed an application to Hibiya High School. I passed the examination. I got my long hair cropped and got a close clipping. Around the time my high school life started, 'The Glass Giant of Palomer' and 'Photographic Atlas of Palomer' were published. The former was a documentary of the five-meter reflecting telescope constructed on Mount Palomer and the latter included many pictures taken with that telescope. The documentary of the large telescope made me think of the vast universe and the



Japanese version of 'The Glass Giant of Palomar' published in 1950.

photographs of the beautiful stars and nebulae which had impressed my young soul. I was fascinated by astronomy, majored physics in the university, and became an astronomer.

1.4

I stayed at the Theoretical Physics Institute of the Kiel University as a student of the Academic Exchange Foundation (DAAD: Deutsche Akademische Austausch Dienst) for three and a half years from the summer of 1961. My professor was Professor Albrecht Unsöld. While the French boat, on which I was on board, struggled with the rough waves of the Indian Ocean, news arrived, ‘A wall to separate the East and West in Berlin.’ It was the time of the Cold War. It happened just after the first space flight by Gagarin in April that year. This event impressed the world and also proved to the world that the Soviet Union was superior to U.S.A. in the space race.

In front of the protestant student dormitory where I began to live, there was a park where swans swam. There was also a meat store nearby the intersection. About a month later I was buying sausage and cheese at this store. The storeowner asked me,

“You’re a student, aren’t you? Where did you come from? China?”

He was clad in a white working clothes and had a reddish face and a strong build.

“No, I came from Japan.”

The storeowner started to smile when he heard the words ‘from Japan.’

“So, what are you studying?”

“Astronomy.”

“OK. I am making sausage so that you can eat it. When you find out something in astronomy, let me know.”

My heart sprung upon hearing those words.

‘Germany is a country of science. In Japan, the word ‘astronomy’ makes people think as if he heard a magic word of a wizard. In Germany, an astronomer is, like a butcher, a profession, which happens to be a common profession! '

With this thought in mind, the treetops of the poplar and the steeples of the church, that I used to see everyday, came into my eyes as if they symbolized the power of reason that pointed to the heavens.

Professor Unsöld was a tall man. He was hard to please and was strict although I thought otherwise when I first met him. I heard that he was one of the best students of the famous physicist Sommerfelt. He put much weight on experiments and observations, and criticized theoreticians who did not understand the importance of experiments and observations. A little after the semester began, my turn to meet Professor Unsöld finally came .

"What did you do in Japan?"

he asked me.

"I analyzed the bright ring surrounding the sunspots. I …"

He did not listen much to my explanation and said, looking at me through his glasses with his sharp eyes,

"Well, you may not continue your study of the Sun. Measure these."

Upon saying this, he brought out a few small paper bags from his drawer of his desk on which papers were piled up.

"You identify the spectral lines first,"

he said and then gave me the bags with caution. Glass plates of 3 centimeter width and 10 centimeter length had fine stripes in them. On each of them, he placed numbers with his hand that resembled the trace of an earthworm. I came back to my desk with them and read what was written there. They were the spectral plates of λ Bootis which he took with the 100-inch Telescope of Mount Wilson, California.

The first thing to be done in astronomical observation is the measurement of position. Next, photographs are taken with a blue or red filter. We do not use photographic film now, instead we use an electronic camera. If the starlight is divided into the seven colors of a rainbow, we can estimate the temperature by the strongest color. The surface of a star shining blue-white has a temperature of thirty thousand degrees. The temperature of a reddish star is three thousand degrees.

If we further divide the stellar light into one thousand colors using a spectrograph, we can see fine spectral lines caused by atoms and molecules. Sodium emits light at a particular one thousandth color in orange. Mercury has several lines in blue-green region. So, by studying spectrographic plates which records stellar light in one thousand colors, we know the chemical abundance at the stellar surface. If we divide the light into ten thousand colors, the width of spectral lines particular to each atom and molecule and their shift in the wavelength shows us the density and motion of the material.

I knew this through textbooks. I had the experience of measuring a spectral plate with one hundred colors at the Department of Astronomy located at Azabu, Tokyo. But the plates had ten thousand colors, and were taken by Professor Unsöld himself. So, I took great care so as not to break them.

The Institute of Theoretical Physics of the Kiel University was a small institute with seven staff members and four or five post graduate students who were aiming at a Ph.D. thesis. In Germany, as far as one is qualified, he/she can enter a university whenever he/she wants. There is no regulation on the age. So, grade levels did not exist. There were students who were quite old. The staff had their own office. The students occupied a large room that was full. I was an extra. I was given a small desk next to a bookshelf in the library. The desk was located by the window at the bottom of the room. A measuring engine was put on it. It was a microscope with a micrometer, which allowed measurements of position with an accuracy of one micrometer.

One day, Assistant Dr. Baschek came to me with a message from the Professor. He asked me,

"Will you work part time?"

He was small and shorter than I. Because of this, it was easier for me to get along with him than with ordinary Germans who are usually tall and thin. His hair and eyes were light and thin as most of the people in northern Germany.

"Part time pay is three marks per hour. How about working twenty hours per weekend? You can calculate table of ionization of atoms using an electronic computer. I think it will benefit your research."

Although I was hesitating to make a decision, he decided that I do it and explained how to calculate the table. The electronic computer was called 'Zuse XI.' It was the most modern machine in Germany and had four thousand memories. I had never touched an electronic computer by that time. The only experience I had of this kind was with an 'electric calculator' with four memories. Dr. Baschek taught me patiently how to use it, and I started the calculations. Everyday I stared at the computer program in the corner of the library and punched holes on the computer tape. After two weeks I brought the results of two overnight calculations to him. He was very glad and said

"You are the first student who made no error at his first attempt."

I was highly evaluated due to this fluke. Instead of the busy Professor Unsöld, Dr. Baschek and the associate professors began to take care of me. After half a year, I finished the measurements and submitted the results. Professor Unsöld said nothing and gave me the next plate.

1.5

Everyday I carefully measured the spectroscopic plates Professor Unsöld gave to me. At the same time, I hunted for references on stars. My desk was small and was located in the library near the window between book-shelves. But it was good while I worked on my measurements because no one came close enough to disturb me. The only thing that worried me was the distance between the plates and the steam heater. I was worried that the lengths of the plates would change due to heat. So, I checked for differences between the measurements taken on the day and those of the day before, and also checked the measurements taken during the start and at the end of the day. One micrometer difference could result in a difference of the stellar velocity of one kilometer per second. This amount of error is quite large for an ordinary star like the Sun.

The star I was told to analyze for my thesis, HD161817, was thought to belong to the 'Population II' because it was moving at a faster speed as compared to the Sun. Astronomers named ordinary stars like the Sun as 'Population I' and named the stars quite different from them as 'Population II.' Stars of 'Population I,' which are located in our Galaxy form the high-density lens-shaped disk and go around the center of the Galaxy in two hundred million years. 'Population II' stars are not confined in the disk and move freely in the low density spherical region called the 'Halo.' When a 'Population II' star comes close to a 'Population I' star, the relative velocity may exceed one hundred kilometer per second. From studying the most recent papers, I found that the astronomers in the frontier think 'Population II' stars are the old stars born during the early phase of the history of our Galaxy.

How can one know if a star is new or old? A star shines because of the nuclear reaction taking place at its center; therefore it earns its name as a 'natural nuclear reactor.' This natural nuclear reactor is comprised of hydrogen and helium, which are part of both the fuel and the wall material. The center of a massive star has a high temperature and due to the rapid burning of the fuel, the fuel is soon exhausted. When the wall starts to burn, the mechanical balance attained in the preceding phase is lost and the outer region of the reactor starts to expand rapidly, thus forming a red supergiant star. The star, then, reaches the end of its lifespan. Therefore, the most massive star in a group tells the age of the population. Among the high velocity 'Population II' stars, there is no massive high temperature star. Such stars are supposed to have burned out long time ago.

My star was quite massive compared to the other 'Population II' stars, so it was supposed to be a rare star just before the burn-out process. My job was to measure the spectral plates and determine the surface temperature, pressure, gravity, and chemical abundance. Then, with the results of the spectral analysis, I was to accurately diagnose the mass and age of this natural nuclear reactor.

‘Is it possible definitely to prove my results? Why the chemical abundance of that star differ from that of the Sun?’

I got totally absorbed in solving this riddle. Old stars are distributed in the Halo-part which extends to the outer part of the Galaxy. Young stars form a disk inside it. I gathered data of spatial motion of stars and analyzed them in my own method. I thought,

‘There is something interesting here.’

One day, a new paper was read at the seminar. The working hypothesis was as follows: Our Galaxy was spherical at first. Population II stars were born when it was collapsing toward the center. When the collapse proceeded to some extent, the system started to rotate and the centrifugal force became dominant to form a disk. Population I stars were born at this phase. The paper said that heavy elements made by the massive stars of Population II were inherited by Population I stars, and the Sun and the Earth were born. I realized that other researchers thought of similar ideas when I reached the idea.

I measured the wavelengths of spectral lines of iron, sodium, and calcium that appeared below the microscope, and started to measure the intensity of the spectral lines using a measuring machine. The biggest job of all was to determine the theoretical model of the wall of the natural nuclear reactor that explains the results of measurements consistently. Later, I learned that this was the main theme of the research project run in the Institute for Theoretical Physics of the Kiel University.

While I was absorbed in my research, Professor Unsöld wrote a letter to the German Association for Academic Exchange and got an extension of the scholarship for me towards the second year. I planned to stay in Kiel until I get the degree, but I did not think of the next year at all because the best I was able to do was just to live the day. I was exempted from the tuition and had some money in my bank account. So, with a little more money coming from my part-time job, I thought I could make a living.

Fräulein Uta Schumpp, who later became my wife, majored in sociology while working part-time in the foreign student section of the university. She was also the chairwoman of the female students of the Catholic dormitory. She was small and had short chestnut-colored hair and gray-green eyes. In northern Germany, Catholics are few. Most of the students of the Catholic dormitory were from the southern part of Germany. Uta was born and raised in Mannheim in southern Germany. The dormitory stood on a green hill near the pier for the water-bus that ran through the fiords. It consisted of a three storied main building and a church, and had a merrier atmosphere than a protestant dormitory. A catholic father and three nuns lived there to take care of students. The father, small and with faithful looking eyes, wore maroon monk suits. He took tender care of the students. However, the operation of the dormitory had financial difficulties. He may not have had the ability in this field.

I got acquainted with Uta through yachting. Kiel University had three yachts that were donated for the international friendship. It was necessary to have a participating foreign student for a yacht tour. I had a master license of Japanese swimming 'Shinden-ryu.' I liked the sea. So, I often offered to be the necessary foreign student. When my stay in Germany was reaching two years and my visits to Uta's dormitory became quite often, the nuns got quite uneasy and asked her,

"Fräulein Schumpp, is he a Chinese?"

"No, he is a Japanese."

"A Japanese?"

Long time ago, submarines would have left the port of Kiel for the allied country Japan. But at the time of my stay in Germany, Japan was quite a distant country. No news came from it. Germany was in the midst of the Cold War between the East and West. So, such an indifferent attitude toward Japan was quite natural. The news often reported of people shot to death because they tried to go to the other side of the Berlin Wall. In the meantime, President Kennedy of U.S.A. was assassinated. There was even a meeting with a theme,

"What are we Europeans?"

which reminds us of the end of the century. The Social Democratic Students Union had the university under its thumb.

At the end of the third year of my stay in Germany, I got the degree, married Uta, and after a while, returned to Japan alone by boat. I got a job of an assistant at the Tokyo Astronomical Observatory at Mitaka. Uta gave birth to our first daughter Yoko Monique, and got a master's degree in sociology. She came to Japan one year after me which was also one year after the Tokyo Olympic. Life in Tokyo was not easy, but we were full of expectations to start our new lives as grown-ups.

1.6

Mount Wilson Observatory is located five thousand feet above sea level on mountain ridge, and commands a view of the plain of Los Angeles. That night, when the clouds covered the sky around midnight, I stopped my observations and read research papers under a desk lamp. The light of the desk lamp attracted the moths, which filled the window screen in front of me.

On the ridge of Mount Wilson, besides the 100-inch and the 60-inch telescopes and solar telescopes of several sizes, which stands before a proud history, a modern infrared telescope was operating. Ever since I came to the California Institute of Technology as a guest researcher, I was endowed with an environment that allowed me to use either the 100-inch or the 60-inch telescope four or five nights per month. The spectral plate, from Professor Unsöld, that I analyzed in Germany was actually taken with the 100-inch telescope of this observatory.

In Japan, the 74-inch Telescope was completed and was already in operation. I was completely unaware of this when I was a graduate student in Germany. When I came back from Germany and became an assistant at the Tokyo Astronomical Observatory, Japanese astronomers were using this telescope quite often. This 74-inch Telescope of the Okayama Astronomical Station built in 1960 was the result of great efforts achieved by the leaders of Japanese astronomy: Yusuke Hagiwara, the one who revived the Japanese astronomy after World War II, Yoshio Fujita known by his study of low temperature stars, Kiyoteru Osawa, a pioneer in the study of peculiar stars, and Zenzaburo Suemoto with brilliant achievements in solar physics. It opened the door to the observational study of stellar physics. The astronomical society in Japan was in an activated stage.

I learned a new methodology of spectral analysis of stars in Kiel. When I came back to Japan, I was engaged in the study of a peculiar star, HD221568, under the supervision of Professor Osawa. The mass of this star was two to three times larger than the Sun, and its motion apparently suggested that it belonged to the Population I. The chemical abundance of this star was peculiar. This peculiarity, however, was not one that reflected the evolution of the Galaxy, but showed some peculiarity of the structure of the star. Its brightness and chemical abundance changed regularly with a period of one hundred and sixty days. The simplest interpretation was that the star has patterns on its surface as the Earth has continents and the rotation of the star makes its appearance change. It seemed that the star has continents where silicon, titanium, or iron is strong, and their spectral lines changed periodically. A group of stars of this type, ‘A-type peculiar stars,’ was already known. The period of the spectral change of HD221568 was the longest among the A-type peculiar stars. As one rotation took one hundred sixty days, many assistant researchers were cooperating to gather a complete set of data. This


Dome of the 74-inch telescope at Okayama (1960). ©NAOJ

was a seventh magnitude star that Professor Osawa discovered in his peculiar-star survey with the 74-inch telescope, which was completed at Okayama.

Besides this, the telescope at Okayama produced the results of the spectral classification of low temperature stars. This task was performed by Takashi Tsuji, who was one year younger than I, along with Professors Yoshio Fujita and Yasumasa Yamashita. It was around that time that X-ray observations resulted in the discovery of an ‘X-ray star’ Sco X-1. Professor Minoru Oda, the founder of the Japanese X-ray astronomy, and Dr. Jun Jugaku worked together and contributed to the identification of the star in optical light. Professor Minoru Oda just came back from U.S.A. after attending MIT. Dr. Jugaku came to the Tokyo Astronomical Observatory from California Institute of Technology a little before my arrival, and was stimulating young researchers.

If a star emits X-rays, its optical light may be abnormal. With this idea in mind, Dr. Jugaku and his collaborators exposed the star two times on one plate, first with a blue filter, then with a red filter. In the field they were watching, an abnormally blue star was found. With this doubly-exposed two-color plate of the star on hand, Dr. Jugaku discussed enthusiastically with Professor Osawa,

“What do you think? What kind of star is it?”

Eventually the U.S.A. team found the true nature of the star. It was an ‘old novae.’

A ‘nova’ is a star that starts to glow suddenly although it was previously faint. The name was given to such a star because it appears as if a new star is born there. Actually, it is known that when hydrogen gas accumulates on the surface of a high-density star, the nuclear reaction is ignited at the bottom of the hydrogen layer and the accreted layer explodes. When a star like the Sun becomes old and exhausts the fuel inside, its exterior part expands while the gravity makes the central part contract until the limiting density is reached. Most of these high-density stars are made similar to this way. If this star is a component of a binary system, the gas cloud from the other star is accreted to the surface of the high-density star via rotating disk.

When the gas accumulation reaches a certain amount, it ignites. Therefore, it is not rare that a nova phenomenon repeats. Like volcanoes, some of them become dormant, and some others dead. They join ‘old novae family.’ Immediately, theoreticians attacked the riddle of ‘why does this old nova emits strong X-rays.’ “We lack experience,” said Dr. Jugaku when he learned that the U.S.A. team was the first to solve the riddle.

Such was the atmosphere of my workplace. I visited the Okayama Astrophysical Station often, and continued my study of HD221568. My senior colleagues like Shiro Nishimura have been working on the development of instruments from the start of the Okayama Astrophysical Station, and Kyoji Nariai, who was one year younger than I, was an active observer. As I was an inexperienced observer, I learned a lot from them.

Some of the ‘A-type peculiar stars’ are known as ‘magnetic variables.’ I made a prototype instrument to measure the sunspot’s magnetic field when I was an undergraduate student under the supervision of Professor Wasaburo Unno. I also analyzed data of sunspots for the Master’s thesis. I was especially interested in this ‘magnetic variable.’ It seemed to me that the surface of this star was covered by a strong magnetic field as if the entire star is a sunspot. Some parts, other than the southern and northern magnetic poles, showed a strong magnetic field that seemed to be related with the continental patterns of silicon, titanium, and iron. The magnetic field of HD221568 had not been measured yet because the star was faint. However, the star was thought to be one of the magnetic variables.

‘Why do such strong magnetic fields exist? What causes the peculiar chemical abundance? Is the magnetic field responsible for that? How are the variation of brightness and the variation of the magnetic field related to the chemical abundance? The Earth’s magnetic pole moves in long periods. Do the patterns on the surface of magnetic variables change? ’

For two years, I devoted myself to the study of HD221568 and wrote a thesis for a doctor of science in Japan, because, at that time, a degree of a foreign country was not evaluated officially in Japan. It was not counted as an item in the professional career for a government employee.

During these years, my life was blessed as far as the research side was concerned. However, in Japan, the profession of an astronomer was thought to be a profession chosen by an odd person. It was, so to speak, a kind of hobby or fun. In Germany or in the U.S.A., it was considered an established profession, and every citizen knows that astronomy is important as the origin of science. To my regret, I could not experience that refreshing feeling in Japan. Foreigners were few at that time in Tokyo. So, the daily life with a German wife was full of troubles that were unexplainable to others. Uta took part in the German course on TV and taught German at the Goethes Institut. After the birth of our second daughter Keiko Annette, taking care of the children took up much of her time. Life in Japan took a hard toll on her. I do not know if my boss knew this, but he said to me,

"Won't you go to the California Institute of Technology?"

I agreed immediately, closed down my house, and got on board a ship. I submitted the doctoral thesis before I left for California, and the degree was awarded after my departure.

The city of Pasadena, where the California Institute of Technology and the headquarters of Mount Wilson and Palomar Observatories were located, is the capital of observational astronomy. At the seminar which I began to attend, the following were present: Maarten Schmidt, the one who discovered 'quasar,' Martin Rees, the world's authority of cosmology, Bob Oak, the one who was the leading person in developing instruments, and young and bright Wallace Sargent. The discoveries of puzzling celestial objects 'quasar' and 'pulsar,' were reported, and the seminar was exciting. A 'quasar' looked like a star, but showed a large red-shift. A 'pulsar' flashed regularly in radio waves. When 'pulsar' was discovered, Dr. Rees presented a private letter from Professor Hewish from the U.K. with a comment

"Do not tell it to anybody."

The letter said,

"Celestial objects that emit radio-waves regularly like a lighthouse were discovered. They may turn out to be a lighthouse for space navigation. We are currently continuing our survey."

Soon, the fourth pulsar was discovered, and it was published that a pulsar is a natural phenomenon.

Life in Pasadena endowed a relaxing environment to our two daughters. But the person who appreciated the Californian life most was Uta who was quite tired of a life as a 'gaijin' (foreigner) in Tokyo. As soon as we moved in a house with a lawn and garden, which was located five minutes away from the university, she joined the 'wives of astronomers' club, and recovered her vitality.

While looking at the screen window where the moths were flying around, I thought afresh of my luck of observing stars at Mount Wilson. During the observation of Population II stars with Professor Greenstein, who had the equal status as Professor Unsöld as the world's authority in astrophysics, and Dr. Oak, who was quite active in developing instruments, I was allocated the observation time of the 200-inch Telescope of Mount Palomer. Contrary to the situation, the paper I opened on my desk that night was focused not on stars, but on 'galaxies.' I could not forget the miraculously figured galaxies that were printed in the 'Palomer Sky Atlas' from my boyhood. A galaxy is a group of stars in the universe, which is at such a distance that even light takes millions of light-years to reach their destinations. Hundreds of billions of stars like the Sun gather and shape together as a spiral or elliptic galaxy. Light takes tens of thousands of years to fly from one end to the other of the galaxy. Our Galaxy is one of such galaxies and uncountable numbers of them exist in this expanding universe.

'If the Population II stars that I studied for my doctoral thesis in Kiel reflects the history of the birth of our Galaxy, what are the histories and structures of other galaxies? '

I was quietly aiming at the observational study of galaxies.

About seven decades ago, Dr. Hubble and his colleagues made observations with a 100-inch telescope of Mount Wilson. It was made clear that the Andromeda nebula is outside of our Galaxy, and is a group of stars of the same size as our Galaxy. They cracked the prejudice concept that 'Our Galaxy is the Governor of the world of stars.' Next, they discovered the 'Redshift of galaxies,' and showed that the more distant a galaxy is, the more rapidly it is flying away. This was the starting point of the observational cosmology. With the paper open on the desk, I kept thinking until dawn,

'I wish to observe galaxies. I will try to observe galaxies while I stay here.'

The dormitory of the Mount Wilson Observatory is called the 'Monastry.' Each room had a simple wooden desk, a bed, a chair, and a stove that was very inconvenient to handle. Drs. Virginia Trimble and Judith Cohen who later became famous female astronomers were visiting the Mount Wilson Observatory as young researchers. However, they were not allowed to stay at the 'Monastry.' Instead they stayed at a guest building called the Kapteyn Cottage. Meals were served two times a day, at noon and evening, punctually with the words,

"Good Morning, Boys,"

"Good Evening, Boys."

Late sitting was not allowed. To the lady who was working in the dining room, a professor was one of the 'boys.' She complained that 'girls' sat late or that their clothes did not match the table manners. Telescope usage established the seating order at the table. When I used the 100-inch Telescope, I took the top seat. Observers of the 60-inch Telescope had to carry the baskets filled with canned foods for the night meal to its designated cottage built between the two domes. When I offered to carry the basket for a professor with white hair, he answered,

"I will carry the basket. No, not by all means. If you do it, it may rain. We have been doing this for half a century."

Mount Wilson Observatory was in construction from the end of the nineteenth century to the beginning of this century. The 100-inch Telescope was built in 1917. An album made of the time of the construction was located in the lounge of the 'Monastry.' I used to arrive at the room fifteen minutes early before the meal and looked at the photographs of the album. Men with pot hat and frock coats were on horses and climbed steep slopes of the mountain. Astronomers who came to this land from the eastern states looking for a clear beautiful sky had the countenances of pioneers. By traveling on a narrow road, they brought over the 100-inch mirror on a horse cart. Fifty years ago, they built a telescope larger than the telescope at Okayama, which was the largest in Japan. With the enthusiasm of a youth, from Mount Wilson, I wrote a letter to Professor Osawa,

"Let's try harder. I wish to live in the Okayama Astrophysical Station and observe galaxies. I wish to build a larger telescope."

Such was my letter. I got a letter back from Tokyo. It said,

"You are still young to think so simply. Actually, there are many problems. The first thing you should concentrate on is to publish the results of your research. Education of students is also important."

In the summer of the second year, I started my long awaited observation of galaxies. Since I did not have a career in this field, I applied for observation time with the spectral analysis of Population II stars. I secretly prepared observation of galaxies in-between star observations. A star is seen as a point. An ordinary galaxy extends faintly like a nebula. I tried a long time exposure with a rapid spectrograph, but no trace was found. Then, I reached an idea of observing

Stephan's Quintet (One of the famous compact cluster of galaxies)
©Kiso Observatory (Institute of Astronomy, School of Science, The University of Tokyo)

‘compact’ small galaxies. Professor Zwicky of the California Institute of Technology discovered exceptionally compact galaxies while surveying galaxies and published a catalogue of his findings. I selected the most compact galaxies to observe. A faint spectrum was obtained. The plate showed a broad hydrogen emission line that suggested exploding-like activity occurring.

During my two year stay in California, our third daughter, Aiko Michelle, was born. At the end of the year of 1969, which was just after the manned-flight of the Apollo spacecraft went to the moon, we headed back to Japan with hope once again.

1.7

In May, 1980, a little before my trip to Chile for observations, severe discussions were made at the annual meeting of the Astronomical Society of Japan on the plan of the next telescope of Japan. Specially, the gap was large between the idealism and realism on whether it should be built ‘in Japan’ or ‘abroad.’

One of the pioneers of observation from the space, Professor Yukio Hayakawa told me,

“Science itself realizes big scientific projects.”

I thought,

‘It may be so because it needs thoughtful planning, continuous passion, and a kind of power to persuade. I have to itemize the problems, and solve them one by one. It is still not clear if ‘constructing abroad’ of the next telescope is impossible. I should make a thorough survey before I give up, if I should ever give it up.’

“We had better make survey of the possibility of constructing it abroad,”

I said it almost to myself. Mr. Minoru Shimizu of the Okayama Astrophysical Station, Professor Yasumasa Yamashita, the director of the Okayama Astrophysical Station, and I, were licking ice-cream in a café near the meeting place. Then, Professor

Yamashita who was smoking a cigarette simply said,

"I will study it."

He meant that he would drop by Hawaii, on his way back from the symposium on 'Low Temperature Stars' in U.S.A., and conduct a survey. He stayed at the Institute for Astronomy of the University of Hawaii for one week, and climbed to the Mauna Kea Observatory at 14,000 feet above sea level. He studied many things and brought back a pile of memos: What kind of filings and documents are required for the construction of a telescope; how have U.K. and France done it. His report was an epoch-making step forward for us whose discussions were going round in circles. However, I did not think that the situation was changed by it. Many kinds of filing documents were necessary according to his memos. And it showed clearly the difficulties lying in front of us.

This year, a voluntary group of researchers in related field, 'Group of Optical and Infrared Astronomers,' started. The next telescope problem stimulated its start. Its proposal came from Dr. Keiichi Ishida of Kiso Station of the Tokyo Astronomical Observatory. The Kiso Station, which opened in 1975, had the world's fifth 'Schmidt camera' that had a diameter of 105 centimeters. It allowed photographs to be taken of a wide sky field. Stellar astronomy was actively promoted there. 'Kiso group' headed by Professor Bunshiro Takase, its director, and Professor Tomokazu Kogure of the Kyoto University held a meeting almost every year and offered a place to discuss together.

"Top-down thinking of the leaders of the Tokyo Astronomical Observatory should be avoided. We will make out a good way of thinking discussing together."

This was a nouvelle vague(new wave). A big symposium on the next telescope was held at the Kyoto University. Just after the symposium, the annual meeting of the Astronomical Society of Japan was held in Mizusawa, Iwate. It turned out to be a hard kangaroo court. I was cross-examined of being for the conservative plan of 'building in Japan' of the Tokyo Astronomical Observatory, while I was an associate professor of the Department of Astronomy of the University of Tokyo. At that time, some people thought that the observatory at Mitaka is, in some sense, a local agency of the Department of Astronomy in Hongo. So, the two were in rivalry of some kind. Astronomers of the observatory had the responsibility of operation of routine works while those of the Department of Astronomy mainly did research and education. So, the latter were supposed to be able to think more liberally and with more flexibility.

Some people blamed me plainly,

"You should speak out for building it abroad."

But I totally did not wish to make a proposal of building it abroad. I did not wish to talk irresponsibly.

'As my wife is a foreigner, I knew how bothering are the troubles caused by the cultural and social differences by my experiences. More than anyone else, I wish to build it abroad, at the same time, I know the difficulty caused by it.'

These were what I thought in my mind.

Shiro Nishimura with some others insisted on a 'new technology telescope.' Dr. Jun Jugaku and others insisted on building it at a good site abroad. Every member of the Astronomical Society of Japan had his own opinion, so discussion continued endlessly. I asked Professor Chushiro Hayashi of the Kyoto University about his opinion. Professor Hayashi who did world famous work in the field of the internal structure of stars said with his Kansai dialect accent,

"Well, if they say they should do it, it must be done anyway."

'Who are they? Who does it in the last passive-voice-sentence? Did he mean 'me' by the word 'they'? '

He was criticizing my inconsistency by his cryptic answer quite like in Zen dialogue.

While I was involved in these discussions, I was also studying galaxies and tackling the observation of stars by a balloon borne telescope, and was planning the Japanese Ultraviolet Satellite project (UVSAT). An orbital telescope with an artificial satellite was also attractive. With it, we can observe the universe directly without being affected by the Earth's atmosphere. I wanted to observe high temperature stars in ultraviolet light that couldn't penetrate the atmosphere. The X-ray group of the Institute of Space and Astronautical Science (ISAS) led by Professors Minoru Oda and Yasuro Tanaka, launched small but unique satellites and obtained worldly appreciated results. ISAS has a department of engineering, and its science department has many experimental physicists. The attitude to 'make tools ourselves and observe the universe' takes root in them. As I experimented with the balloon borne telescope with Wataru Tanaka at the Department of Astronomy, I understood their thoughts. In comparing the next large telescope on Earth and the orbital ultraviolet telescope, I would say that I was standing closer to the latter.

In 1981, I was 44 years old. I was asked,

"Would you move to ISAS in a few years if you were asked to move?"

I answered,

"Yes."

My opinion was sounded when the ISAS was going through the restructuring plan into an inter-university organization. Restructuring was done, but my transfer to ISAS was not realized. Instead, transferring me to the Tokyo Astronomical Observatory began to be discussed. On one hand, it was probably because of the importance of space astronomy in the future, and on the other hand some people thought that I was working with students for too long time.

Uta, who was working in the Tokyo Institute of Technology as a foreigner teacher, did not like this proposal. If both of us are teaching in the universities, we have relatively free time during the summer vacation. If I move to an institute like the observatory, this freedom will be lost. My company will not be students, but officers and technicians. When I am promoted to a professor, I have to take the responsibility of management as a head of a section. But, with a little reflection, it was clear that I was old enough to take such a responsibility. I was standing in a mainstay position of the Astronomical Society of Japan.

‘But, …,’

another part of me says,

‘Just forget about such feeling of responsibility and honor and devote yourself to one of the research theme you like. Won’t you study galaxies, now?’

The quantitative classification of galaxies that I started after I turned back to Japan, was going to show its outline. I felt that something new could be achieved if I worked hard on it with Dr. Sadanori Okamura of the Kiso Observatory and with the students at the Department of Astronomy. It seemed clear to me that, if I do not work hard on it now, I could lose a chance to accomplish a work that could be called as my ‘lifework as a scholar.’ Life with Uta in Japan was getting on well. We built a cottage at the foot of mountains of the Southern Alps in Hakushuu in Yamanashi Prefecture so that we can relax escaping by from our small house in Tokyo. Our three daughters were going to school and were growing well and rapidly. I did not wish to lose the present life.

While I was not able to make up my mind, I was burdened with a lot of work and lost all my spare time. Usually, I’d smoke once in a while, but lately I was smoking quite often.

1.8

In 1981, one year after Professor Yamashita made a survey in Hawaii, I decided to drop by Hawaii on my own expenses on the way back from a symposium in New York. I believed that I could not give up the idea of ‘building a telescope abroad’ without a thorough survey. I wrote a letter to Dr. John Jefferies, the director of the Institute for Astronomy of the University of Hawaii. And the date of my visit was set on a day in autumn.

Drs. Takashi Onaka and Toshihiko Tanabe were with me. I was doing the balloon experiment with them. They were on their way back from the mainland. We met at a restaurant in a hotel near the beach of Waikiki. The next day, we visited the Institute.

The day after, we headed to Mauna Kea. Forty minutes after the small airplane took off from Honolulu, it arrived at the Hilo airport on the Big Island which is located at the southernmost part of the Hawaiian Archipelago. Hilo is the capital of the Hawaii County. On the way to Hilo, as the plane flew the eastern side of Mauna Kea, I saw white domes on the summit shining like speckles. Many deep green valleys of tropical forests cut the skirt of the mountain.

It rained in Hilo, as what it's famously known for. In old times, this area had a lot of cane fields. Many Japanese immigrants came to work in the cane plantations. The Hilo airport was wide and I began to feel that I truly came to a tropical island. I was told to use a vehicle of the University of Hawaii parked in the parking lot of the airport. In the letter I received, it was written, "The key is in the ashtray of the unlocked car." I found the vehicle with a sign of the University of Hawaii (UH) easily. The key was in the ashtray as was indicated.

We passed by the town of Hilo which extended along the beach, and headed up towards the mountain. Hilo is a town with a population of thirty thousand. The capital of Hawaii, Honolulu, is a city with a population of one million people, but Hilo, the second largest city in Hawaii, is quite small. It must have been a big town with a lot of immigrants as the capital of the county, which produced cane in big quantities. Most houses were flat or two-storied. The three-storied concrete building was the government building. Soon we passed by an area of residences surrounded by flowers, and were driving on a mountain road through the green woods. The pavement of the road was broken here and there, making the drive rough. It curved not only left and right but also up and down. Sometimes Mr. Tanabe's driving was a little bit uncertain.

About after an hour, air changed from hot and humid to refreshing. We got out of the sea of trees to the lava plain. The entire island was made of lava. Trees and grasses grew on the old lava. It was drizzling, and suddenly visibility became poor. We were probably driving into clouds. When it cleared up, we were in a sea of lava. This 'Saddle Road' crosses from the east to the west between Mauna Kea and Mauna

Loa, two fourteen-thousand-feet mountains. Unlike a saddle in Japanese mountains, the highest point is in the middle of a flat lava plain. The blue sky peeked beyond that point. As the two high mountains made the water vapor carried by the trade wind fall as rain before the saddle point, it is always clear beyond it. A hunter checking station is located near the highest point. There we turned right and started climbing Mauna Kea. We went through a big ranch. It seemed there is a source. We passed by a herd of cows. The road was straight and steep; soon we gained altitude rapidly. Then we were on a mountain road full of rocks, with many curves. Professor Yamashita wrote in his memo last year,

"Tremendous jolting on this rough road often makes the observational instruments function improperly."

My young colleagues seemed to enjoy driving. Just when I started to feel uneasy about the drive ahead of us, we were above the clouds and the mid-level facility of the Mauna Kea Observatory called 'Hale Pohaku' was right in front of us.

It was 9,000 feet above sea level. Those who observe or work at the summit usually stay and eat meals there. At the summit where the air is as thin as sixty percent of the air at sea level, it is not good for sleeping. The building was a wooden flat house with fifteen single rooms, restaurant, and common facility like shower and toilet. Surrounding it were shrubs. It was almost desert-like. The long slope was reddish rock-soil. A little above the dormitory building, I saw vehicles for road maintenance, a machine shop, a generator room, an oil tank, etc. When I got off the car, I felt a little weak. It was caused probably by the direct ascent from the sea level. I got out of breath when I walked. I walked as slowly as possible as was recommended in Professor Yamashita's memo. I could not see the summit because a hill blocked it. Below me was a sea of cloud.

"Welcome to Hale Pohaku. The director told me that you are coming."

The head of the mid-level facility said with his massive body swaying.

After a little rest, we headed to the summit. A staff of the Mauna Kea observatory drove the vehicle. This road was steeper and more rough than the road below Hale Pohaku. I endured the cloud of dust raised by the vehicle. The jolting made breathing difficult. The driver put on a mask to protect against dust. The ascent continued endlessly. Small hills of volcano ash appeared one by one. It was almost a scene on the moon.

“This is the trace of glacier. The rocks over there are round shaped. Do you see the difference between those rocks and other rocks?”

“On the left, there is a place called Adze Quarry where, in old days, people of this island got hard rocks to make tools.”

“There is a Lake Waiau if you turn left here and walk fifteen minute.”

The driver kindly explained with his mask on his mouth. I did not listen to him carefully as I was trying not to get car-sick. I may have bitten my tongue if I opened my mouth thoughtlessly.

When we finished climbing the last hair-pin curve, we were on a wide ridge and could see many bright domes. There were three large domes and two small ones. The closest among the large ones was the United Kingdom Infrared Telescope (UKIRT, 4 m), standing next was the 88-inch telescope of the University of Hawaii (2.2 m), and the large white dome was the Canada-France-Hawaii Telescope (CFHT, 3.6 m). In small domes were installed 24-inch telescopes (0.6 m). From the sea of clouds was rising cumulonimbus. Above us was the deep blue sky. I felt that I might be sucked into that blue sky at any time. In the north, the Haleakala of Maui showed its summit above the clouds.

Aerial view of Mauna Kea Observatories before the construction of Subaru Telescope. In the background is seen Mauna Loa. ©NAOJ

“From Haleakala, Mauna Kea is always beautiful like this. That’s why constructing telescopes on this summit was planned in 1960s. …”

The driver’s explanation continued. Kona side that lies on the opposite side of Hilo was clear and I could see the white coastline clearly. The sea showed stripe pattern as if it were brushed. On the south beyond the sea of clouds, Mauna Loa was standing with its wide skirts. On Mauna Loa, a crater near the shoulder was still active. The active volcano Kilauea was on the other side of it.

We visited the 88-inch telescope of the University of Hawaii. Telescopes of this size usually have framed structure to support the mirrors. But this telescope had a tube and looked quite solid. Compared to the telescopes I used to see, it was roly-poly looking. We saw the wide spectrograph room, the electronic shop on the stair below, the machine shop, the dark room, the oil-pump room, and the aluminizing vacuum chamber with which a thin aluminum foil is put on the mirror once a year. I got out of breath and had a little bit of headache.

“Walk slowly. If you don’t feel well, say it to me. We have to be careful not to get altitude sick. We have an oxygen tank.”

said the man and guided to the next place. The building was equipped with an elevator, but when going up a little bit, we did not use it. In such cases, the stairs were a little bit hard for me. We also went to CFHT and UKIRT to see them briefly. CFHT is a telescope of equatorial mounting of classical refined design. It was really big. We did not spend much time there. Approximately two hours passed since we came to the summit. Inside the domes, it was cold. That made us feel worse. How relieving the sunlight was when we got out of the building. It was windy, but when we stayed where the wind is shielded, the sunshine kept us warm. I could not believe that we were at a height of 14,000 feet above sea level.

“This is the world’s highest mountain if you measure the height from the bottom of the sea.”

Our guide extended his arms to show that he is not tired. Probably, he is used to this altitude.

“That is the true summit of Mauna Kea. That is the sacred place and is kept undeveloped. However, it is allowed to walk it up. Will you try it?”

“No, thank you. I will try it later.”

We started descent. As I went down, I felt better.

At Hale Pohaku, it was not raining.

“Will you come and see ‘Hale Pohaku’? Hale Pohaku means a stone house in the Hawaiian language. In old times, it was a hunting cottage. Do you see a stone cottage with a door over there? That’s it.”

“What do they hunt here?”

“Antelopes, wild turkeys. Hunting season is limited. We are in a reservation area.”

As I saw around, I saw no kind of animals or birds.

“Come again. An observer is going down. He will give you a ride.”

He was a student from the East Coast of the mainland. His driving skill was no better than Mr. Tanabe’s. He sent us to the hotel near the beach.

We could drink beer that night as our visit to Mauna Kea was over. We went out to a Pizza Restaurant thinking it may be expensive at a restaurant of the hotel.

“Do you think Japan can build a telescope on Mauna Kea?”

I asked my two young colleagues for their opinion. The younger, Mr. Tanabe said,

“I don’t think we can. The present Japan cannot build a telescope there.”

His opinion often makes discussions into turmoil.

“You probably are right,”

I answered. In one sense, I was seconded, but at the same time, I was expecting something different.

“Do you think the same way, Mr. Onaka?”

“Well, it depends on how we proceed. If we work hard for it, we will be able to make it."

This is the expression he is fond of. We should be careful of this 'work hard for it.'

"There are people who passed away because they worked hard. Aren't you taking it too easy?"

"Yes, you are taking it too easy,"

Mr. Tanabe joins the discussion.

"Professor Kodaira, are you going to make it?"

Mr. Tanabe's question is directed to me. We ordered another beer.

"I am thinking about it. That's why I asked for your opinions."

That night, I thought it over, but I could not reach a conclusion.

The director of the Institute of Astronomy, John Jefferies, associate director Sydney Wolf, and secretary on the Mauna Kea Affairs Ginger Plasch patiently answered my questions, and made out necessary documents and copy of data.

If a foreign country including Japan wishes to construct a telescope, the University of Hawaii is ready to accept the request. The first step is to exchange a Memorandum Of Understanding (MOU), then make a draft of the Operation and Site Development Agreement (OSDA) on the construction and operation of the telescope. At the same time, a site is selected. The summit area of Mauna Kea is owned by the State of Hawaii, and is leased to the University of Hawaii. The University of Hawaii subleases a part of the land to foreign countries. A part of the telescope time is allocated to the University of Hawaii so that the University can use the telescope to make academic contribution. As a telescope is built in the reservation area, a public hearing is held. After that, the Department of the Land and Natural Resources judges if it is OK. An environmental assessment must be made before that. Surveys for the prehistoric sites, vegetation, fauna, drainage, etc. must be included in the assessment. Electricity is generated by diesel generators at the summit. If the required amount is too much, this may be a source of environmental pollution. Water is carried up by a tank truck. Common expenses such as the operation of the Mid-level Facility and the maintenance of roads are shared by the observatories. The State, the University, and the participating countries of the Mauna Kea Observatory have already invested considerable amount of money. A newcomer must pay an amount of money that is used for construction or improvement of infrastructure. After all the procedures are complete and before the construction, the Agreement must be executed. It is necessary that dormitories for construction workers are built before the execution. As the site is within the reservation area, the building must not be temporary ones. This construction must go through the environmental assessment.

"I will explain the rest to you later. Ask anytime if you do not understand what I talked today."

So told was I. But I could not specify what I could not understand. It might be said that everything was not clear to me. I put a pile of documents in my suitcase, and left for Japan. The last document that I received at the lobby of the Honolulu airport was a copy of the large map of the mountain.

I hoped vaguely, 'Astronomers' zeal to reach the edge of the universe and the noble shape of Mauna Kea have something in common. So, our plan will certainly be understood by every party concerned.'

[Published] **Keiichi Kodaira/Kyoji Nariai**: **2016**, NAOJ-Books : Makali'i in Hawai'i.

Chapter 2

Looking forward to the Border

2.1

In 1982, I applied for the "Revisiting Program" of Deutsche Akademishe Austausch Dienst (DAAD) and was admitted for a trip to Germany. During the summer vacation, Uta and I spent three months in Germany. DAAD has a system to invite those who used to be students of DAAD and have achieved to become scholars in the field they studied in Germany. I took this opportunity to stay in the Max Planck Institute for Optical Astronomy. During this stay, I attended a symposium held in Catania, Sicily, then went to the General Assembly of the International Astronomical Union held in Patras, Greece. Both the symposium in Catania, Sicily and the General Assembly of IAU in Patras were filled with meetings, but I enjoyed these meetings held near the sparkling coast of the Mediterranean. I also had chances to see the volcano Etna, the ancient theater of Taormine, and the remains of Olympia.

President Bappu of the International Astronomical Union passed away abruptly just before the General Assembly. He was an astronomer representing India, and was the first IAU president from Asia. We missed him very much. Among the Japanese astronomers, there were many committee members or chairmen. But it was only the late Professor Yusuke Hagihara who was among the executive officers such as the president or vice-president. There was an activity concerning of

'Let's invite the General Assembly of the International Astronomical Union, '

but it was thought to be necessary to have a Japanese astronomer to be elected as an executive officer, who would work together with the president.

'Let's do the lobby activity' to invite the General Assembly to Japan. Let's recommend Professor Yoshihide Kozai, who became the director of the Tokyo Astronomical Observatory this year after the term of Professor Suemoto. '

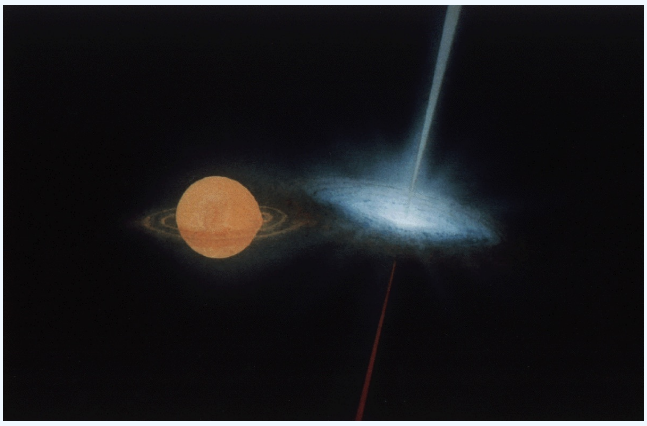
Such was the conclusion after the consultation of several people around me. In Patras, we started to sound towards the invitation of the General Assembly to Japan. In doing so, I was beginning to get worried.

'Astronomers are modest. So we do not need a luxurious Assembly. But can Japan hold an international meeting of Astronomy, when astronomy is perhaps one of the founding science of civilized society? '

Greece is the birthplace of astronomy. Although the auditorium of the university was not equipped with air-conditioning, I felt that their planning had potential power. In this General Assembly, I was elected to be the vice president of the thirty-sixth committee, 'Theory of Stellar Atmospheres.'

I chose the Max Planck Institute in Heidelberg as the place to stay during this invitational trip partly because it was close to Mannheim where Uta's mother Johanna, sickly at that time, lived, and partly because I had spent one year in the Heidelberg University as a guest professor ten years ago. But the largest reason of all was that this new institute was created as a part of the large telescope project of Germany. West Germany not only joined the European Southern Observatory (ESA) and built telescopes in Chile, South America, but also looked for a good site in the northern Hemisphere. It was decided to have an observatory at Calar Alto in the Sierra Nevada Mountains in Spain with a 3.5 meter telescope as its main facility. During the three months of my stay in this institute, when I was preparing for the invited talk on 'flare stars' in Sicily, I had a chance to talk to the director Prof. Elsässar. I asked,

"Why did you decide on Calar Alto?"


SS433 (Artist's image). ©NASA

Calar Alto is in Spain, which meant it was neither in Chile nor in Hawaii. The United Kingdom had already moved a middle class telescope to an island of the Canary Islands, Spain, and has a plan to build Herschel Telescope, which has a diameter of 4.2 meters. Canary Islands are volcanic islands similar to Hawaii. The highest peak, which is 12,000 feet, had good observational conditions. But, because of the steep mountains, the roads are harder than those of Chile and Hawaii. I was told that the evening sky is colored crimson near the horizon because the Sahara desert lies to the East. The big Professor Elsässer smiled saying,

"Because it is connected by land. We can drive a trailer truck from here. It is hard to build a big telescope, but it is harder to maintain and operate it. We build it with the companies, but the responsibility of operation and maintenance is on us."

He said that Carl Zeiss, in Germany, was making the 3.5 meter telescope, and a dome was ready in Calar Alto. A 1.5 meter telescope was already in operation.

The Max Planck Institute was on a hill in Heidelberg. Its ground and first floors almost resembled to those of a factory. The machine shop of the ground floor was especially praise-worthy. I concluded that quite a large observational instrument could be made here. The engineers and technicians of this machine shop were quite enthusiastic. An astronomer without much experience wouldn't even be able to join the discussion of planning a new instrument. For a long time, Germany was a country of excellence in traditional craftsmanship. Fabrication was the base of everything. An infrared telescope that was to be launched on an artificial satellite was being constructed in this machine shop. I estimated that half of the staff members were engineers and technicians.

"Can I observe at Calar Alto?"

I timidly asked what I had mentioned in my letter to him from Tokyo.

"O.K. I have a telescope time reserved for the director. What do you wish to observe?"

"I wish to observe SS433 in the near infrared."

"That's no problem. I will put you in a program allocated to someone else."

My wish was granted as he learned that Japan is planning the next telescope project.

I transferred over to a small airplane at Barcelona, and the next landing was on a sand field off the coast of the southern part of the Iberia peninsula. I took a taxi to the local office, which had only one desk. From there, a driver with a 4WD took me to the observatory. We went through villages clinging to the slopes of white soil, and we came to the top of a hill with open scenery. Creeping pines grew there. That was the Calar Alto Observatory. I immediately saw that the environment with vegetation meant that it was less harsh there than in Chile or Hawaii. I felt that the buildings of the observatory and the lives of staff had something more to spare than only to serve for the function-only purpose because the site was not on a really high mountain.

Dr. Lenzen, an assistant at the institute, gave me some of his observation time. He was studying the structure of the dark nebulae, where young stars are at their phase of birth. The process of birth' is mystic no matter what is being born. The birth of a star is mystic also. How many stars are born? With how much mass are they born with? In the dark nebulae where the interstellar matter is dense, many stars are born at a time. The dark nebulae do not allow visible light to penetrate. But we can see through them in the infrared light. An infrared photometer is attached to the 1.5 meter telescope, and he measures the intensity shifting the direction of the telescope little by little to make the intensity map of the core part of the dark nebula.

I wanted to measure SS433 with the same photometer to know the time variation of the infrared intensity. The star with a catalogued number SS433 emits Hydrogen Alpha emission line. Thus it was one of the candidates of stars with a shining cloud surrounding the star. But recent spectroscopic observations showed that the wavelength of this emission line is shifted by a large amount. If the motion of the light emitting object causes the shift, the velocity of this hydrogen cloud is one over several part of the speed of light, an amazingly large speed. The emission line appeared in two wavelengths, suggesting that the clouds are bi-polar jet flows ejected in opposite directions towards each other.

In the world of galaxies, many examples of bipolar jet flows are found with enormous energy flowing out from the central cores. But, nobody imagined that such super-high velocity jet flows existed in the world of stars. SS433 emits radio-waves as well as X-rays. Spectroscopic and photometric observations with optical telescopes have already revealed that it formed a binary system. Gas is peeled off from one component star, and is pulled to the high-density star such as a neutron star or a black hole. Some kind of physical mechanism works to shoot out gas as a bipolar jet flow. Interstellar matter falls onto a star during the process of its birth. Professor Yutaka Uchida proposed a theory that 'Twisting of magnetic field causes it.' I wanted to see the star in the infrared. The material that was coming from the other component and falling onto the high-density star should form a disk. Its outer boundary part should have a relatively low temperature. And the material thrown away as jets may surround the star as a cloud or dust. If my guess was correct, it could be seen in the infrared. I wanted to see it anyway.

Calar Alto lies almost to the south of Greenwich. But, because it is a part of the continent, the Central European Time is used. During the summer, they use the summer time. Therefore, there is a time difference of almost two hours between the solar position and the clock. When the day crews are off at five o’clock, we eat our supper. The sun is still high above the horizon. We had to wait until ten o’clock to start observing. Dr. Lenzen, the night operator, and I, we waited while sitting in front of the TV. The photometer was sufficiently cooled and we left the dome half-open, facing eastward. Bullfights were being broadcast on TV. After three or four fights were over, it was nightfall. When I went outside, I saw the crimson sky near the horizon in the direction of African continent. That night, the sky was stable. The observations of this trip turned out to be what is called a negative result. Nothing spectacular was found. However, the results were reported in an academic journal with Dr. Lenzen as the co-author.

When I returned to Germany from Calar Alto, Uta told me as usual,

“You should make your own telescope at the best site.”

“It’s not so simple. There are many problems to be solved.”

My thought was swinging between ‘building it in Japan’ and ‘building it abroad.’

“Can’t you build it in Spain?”

“It’s too far from Japan.”

The talk with Professor Elsässer’s made me think that building a telescope in a far place of Europe, like Spain, would make its operation almost impossible.

Our itinerary for the trip back to Japan was to take a night train from Heidelberg to Rome, make sightseeing trip in Rome, and then take a flight to Japan. In the jolting sleeping-car, while I remained wakeful, I thought:

‘Should I devote to the space telescope, or to the ground-based telescope? Or let other people do the both, so that I can devote to the study of galaxies? Sometimes I think I should do this, and sometimes I think I should do others because of the circumstances and positions I am put into. But, the last decision is on me. I have fifteen more years before my retirement age. I should do only one thing from now otherwise I will have to retire without accomplishing anything. My health will be damaged, too. What needs me most? What is the project that nobody else but I can accomplish? ’

Such contemplation led me to ‘building a large telescope abroad.’

‘A man cannot accomplish this task if he does not know the difficulty arising from the word ‘abroad.’ I happened to marry a foreigner. Uta and I knew better than anybody else about the meaning of ‘abroad,’ and the complications coming from countries and borders. This situation made us strongly think to ‘cross the border,’ making ourselves the bridge between different civilizations.’

‘Can I do it for us, not for astronomy’s sake, in order to go beyond the border and to widen the world of comrades who do not care about their nationalities? ’

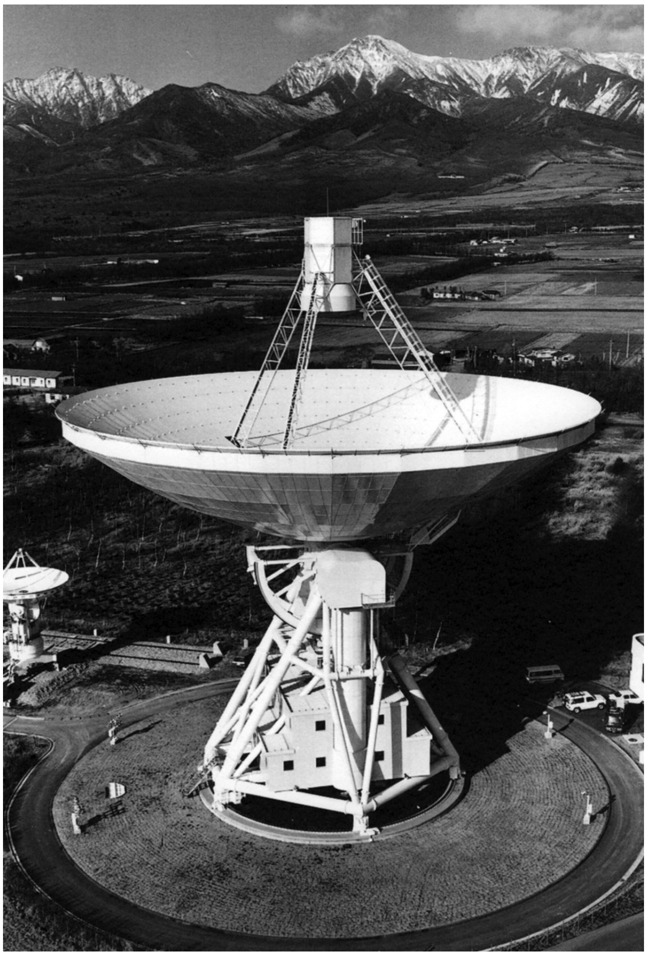
By thinking this way, I felt that I should do it. My reason did not accept my thought of ‘building it abroad.’ But I could not cut the thought away as if it were attached to me by an immaterial force. I felt that I was attaching a reason forcefully in a deep place of my brain.

‘I won’t think any more tonight. ’

I stopped thinking and fell asleep in the jolting sleeping train.

2.2

The destination of the next large telescope project of Japan was still in chaos. A large radio telescope was completed in Nobeyama, Nagano this year 1982, and started test observations. The three to four meter class optical and infrared telescopes in the world were producing results steadily. On the other hand, our discussion on the next optical telescope within the Group of the Optical and Infrared Astronomy was bombarded with troubles.


45 m radio telescope of Nobeyama near the Yatsugatake mountain in 1982. ©NAOJ

The discussion went like this:

"First, with new technology, the Tokyo Astronomical Observatory will build a telescope in Japan that is less than three meters. It should be less than three meters. If it exceeds that size, we will be over-investing for the sky of Japan. Also, if we put too much money in it, it will disturb other requests of funds for telescopes such as the two-meter telescope planned by the Kyoto University. These two telescopes should be built first."

Such discussion reflected the status of Japan to some extent, but it did not make everybody happy.

At such a time, Dr. Liu Cai-Pin asked me if I wished to visit China. She wrote,

"Visit the candidate site for the large telescope."

It was more than ten years ago when the aftermath of the disturbances in universities still influential that Liu Cai-Pin, who was a graduate student of the astronomy course of the University of Tokyo, was unreasonably expelled from Japan and went to the mainland China. The storm of the Great Cultural Revolution, which unluckily she had to face, was over. She was an associate director of the Purple Mountain Observatory, and was one of the Representatives of the People of China. She and her Japanese husband had two children. She was inviting Japanese astronomers to China trying to promote scientific exchange. Liu Cai-Pin, whom I met after a long time, still had a girl-like countenance but her fighting spirit shone in her eyes.

She invited Professor Tomokazu Kogure, chair of the department of cosmic physics of the Kyoto University, Mr. Minoru Shimizu, of the Okayama Astrophysical Station of the Tokyo Astronomical Observatory, and me. She wanted that we see the candidate site for the large telescopes in China during the three weeks tour. China had several one-meter-class telescopes. A solar telescope was producing good results. Construction of a thirteen-meter milli-meter radio telescope was planned. Astronomical Instrumentation Factory in Shanghai was making a 2.2 meter telescope with their own technology only. The next project of four-meter class telescope was about half way. When they prepared a machine shop and started site survey, the project was stopped because of the Cultural Revolution. She suggested that, if Japan is studying the next optical telescope project, we visit the Chinese observatories and candidate construction sites with a possibility of a working partnership. Since I had wanted to visit China for a long time, I agreed to receive her invitation immediately.

The itinerary sent from the Academia Sinica was as follows; The entry point is at Beijing and the exit is from Hong Kong. In Beijing we visit the Normal School and the headquarter of the Beijing Observatory. Then, we go to Korun Station of the Beijing Observatory, and observe stars. Next, we move to Nanjing and use the forty-centimeter telescope of the Purple Mountain Observatory for four nights. Then we go to Shanghai by train, stay overnight, and fly to Kunming, the capital of the province of Yunnan, and visit the Yunnan Observatory. Then we go to Ping Chowan, a town of a small tribe, which is located on plateau close to the border between China and Vietnam. The former candidate site for the Chinese four-meter telescope is located a little distance from Ping Chowan in the mountain area at the height of 10,000 feet above sea level.

It was a fine day of October. We were in Beijing. The scenery was just what I thought China would be around the festival of October 10. We stayed at the guesthouse for the foreigners only, visited the observatory and universities, and were invited to the Great Wall of China and the Mausoleum of the Min Dynasty. Streets of Beijing looked like those in the photo-album of my grand father. Main streets are wide, roadside trees are high, and even the sky seemed to be high. Continental style of the city may not have changed since a long time. It looked more similar to Europe than to Japan. The stars were twinkling while I looked up at the night sky in the observatory. The air was dry, but because of the high latitude, the airflow high above may be turbulent. Mr. Hu, the chief, said,

"The mountains are naked because the Japanese Army cut the woods."

We brought an observational instrument from Japan but something went wrong and it did not work. As we could find no way to fix it, we gave up observation.

The winds in Nanjing were softer and more comfortable than the winds in Beijing. The Tiananmen Square was magnificent but somewhat hollow looking, but the streets of Nanjing were more friendly-looking and had an atmosphere of freedom. Streets have more trees. The Purple Mountain Observatory was like a noted place, and had old instruments. It kept historical instruments such as the 'Kontengi.' Several people were struggling by the request of Liu Cai-Pin to mend the instrument we brought from Japan, but it didn't work. They looked all over the observatory for a coaxial cable and a connector, but could not find them. We caused them great trouble. We tried out many things while staying in the observatory instead of going for sight-seeing, but the instrument went worse than ever. I had brought it thinking:

'As I am going to an observatory, I wish to observe something.'

But I regret,

'I should have prepared more thoroughly.'

The only one good thing was that we got acquainted with each other. We brought the mending work to an end and went out to visit temples and the tomb of Sun Yat-Sen. Liu Cai-Pin accompanied the Japanese astronomers in the sight-seeing boat on the river Yan Tsu Chan. The river was really wide. The gray brown water flew restlessly. I made a sketch of it from the shore.

In Shanghai, we stayed at 'West Town Guest House' known to be the place where Mao Ze-Don usually stayed. We were told that the building is connected to somewhere else by an underground tunnel. Shanghai is a dynamic city. On the shore of Huangpu river, there was a port full of ships. Cranes on the ships were working busily. The buildings of the past concession of the European great powers were now offices of the People's Government. It had an atmosphere of a big city like Tokyo than Beijing or Nanjing had. I bought raw material for stamps, and came back early to my room in the hotel as I was expecting a long trip the next day.

The next day, when I arrived at our hotel 'Kung Min Huan Tiang' after changing airplane several times, it was full of people, as it was a weekend. There was a dance show done by a small tribe. At the entrance of the hotel, there was a poster of a dance party for the hotel guests.

Yunnan observatory was in the suburbs and was large. There were several domes still without telescopes inside, and its research office was big. In a dome in construction, many workers, both male and female, were assembling the materials using their own hands. It resembled a line of worker ants. The main instrument of the observatory was a Schmidt camera of one meter made in East Germany. The director was a meteorologist. He was told to come here by the Academia Sinica. He said,

"I am still not used to astronomical observations."

The engineers came one by one in turn and explained their instruments. I was surprised to see a semi-conductor camera, which one of the engineers made in the U.S. and brought back. In Japan we still could not buy it.

"What kind of observations should I do?"

the director asked us with an open quesiton.

The trip to Pin Chowan, the candidate site for the four-meter telescope, took ten hours with a micro-bus on a rough road. I fell asleep on the jolting seat of the vehicle.

My older colleagues Mr. Shimizu and Professor Kogure fell asleep, too. But the Chinese companions accompanying us were speaking without rest. The loud voices of their discussion woke me up from time to time. We dropped by a gas station to fill up the fuel tank. It was an isolated house and was guarded by soldiers.

Our micro-bus crept up the massive hill region, and below the cliff we saw mountain torrents full of water colored with red soil. From time to time we passed by farmer's houses and tombs. They looked like earthen mounds. Here and there, I saw farmer's figures in the field. They seemed to be poor. I wondered,

'Will they ever be in love?'

It was already at dusk when we reached the VIP guesthouse at Pin Chowan. It was a typical large flat of the Chinese agricultural village. Each member was given a room in the main house within the compound. When we walked in the hall making creaking sounds and opened the door of the room that did not move smoothly, I found inside the room a Vietnamese type bed with mosquito netting lit by a dim light. A washbowl and a roll of toilet paper were delivered to each room. When we needed water, we used the faucet in the garden. The toilet was located in the backyard of a cottage separate from the main building. It was an open drain in the field where water flew. Low boards separated compartments but they did not disturb our chat during our relieving nature. Ventilation was fairly well.

The main dish at the welcome party was carp cooked whole. The dish was cooked with a lot of chili and tasted very hot. The hosts said,

"Eat. Have more."

When we were irresolute, they served the dish for us. And they drank strong liquor.

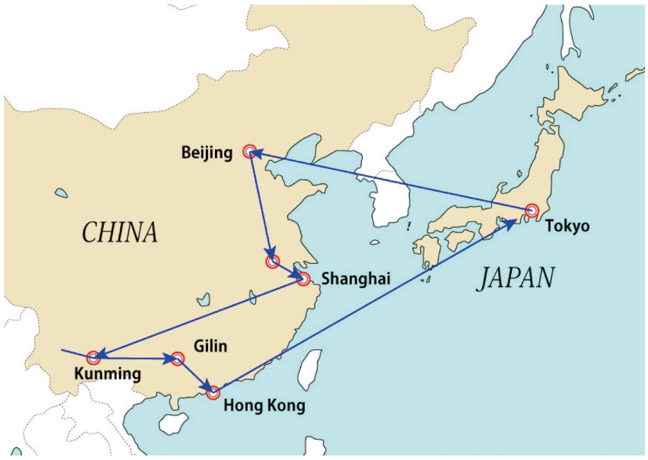
"Kan Pei,"

was the only Chinese spoken at the table. The rest of the conversation was done in English. Several manager class people stood up for toast, then made a speech. Manager class people could speak English a little, but the local people who came to the party didn't speak English at all and were chatting in their own language. Miao Zu people live in the village of Pin Chowan, outside of the compound. They plow their field with sticks. The unroofed market sells groceries and antiques. One concrete building stood at a corner in the village of soil houses. A large signboard put by the side of the front door had a profile of a worker on it with a slogan in Chinese characters. They told me that the building is a community house of the region and movie films are shown there.

In order to go to the candidate site for the four-meter telescope, we first outflanked a steep slope in a four-wheel drive vehicle, then walked up thirty minutes on foot. At the survey location, remains of a concrete base and wreckage of machines were scattered on the ground. For two years, they measured cloud quantity, wind velocity and direction, and humidity. The most important stellar image measurement had not been done yet. I wanted to use the small telescope that I brought from Japan, but I was told not to do so because it was dangerous at night. The land around the site was a farming field of Miao Zu, and is, so to speak, an isolated island in the land. When we climbed up the hill, people of Miao Zu supplied us donkeys so that my senior colleagues wouldn't get tired. The girls of the tribe dressed up to be photographed with us. Eventually, we tried to see stellar images when we got back to the mountain foot, but did not succeed because of the disturbing clouds.

On the last day of our stay, we had a meeting and evaluated the candidate site. The point that worried us most was the high humidity. For the infrared observations, the less water vapor contents in the air, the better. This place was still within the monsoon area. And the public transportation was not convenient. We could not expect engineering support locally. There was neither a machine shop nor a car mechanic. The Chinese participants did not care much about it. But it seemed worrisome for us Japanese. Providing infrastructure supporting the construction and operation of a high technology telescope seemed to be very difficult. If ordered by the Academia Sinica, the infrastructure will be made immediately, but I sank in a complicated thought thinking of the relations between Japan and China that may affect these matters.

Before we left Yunnan, we had lunch at Chuxiong, and stayed overnight at Anning. In Anning, we stayed at an old villa that Zhou En-Lai often stayed at. I was given two rooms. One room was a study and another was a bedroom with a bed with a canopy. The room was probably not used regularly. It smelled musty.



Route of the site-survey trip in China.

The bathroom of hot spring was found after passing a roofed passage. It was an elegant wooden building painted white. At the entrance, a petal of white rose was swinging in the wind of evening.

"This is the changing room,"

said the girl who guided me. Her red cheek seemed quite fresh. I entered the bathroom. The bath made me forget all about the musty room, dusty red brown roads, and inconvenient life at Pin Chowan. The bathtub was rectangular, and was made with greenish granite. The hot water was transparent. It came from the bottom and overflowed the edges. The walls of the inside of the bathroom were painted white, too. The high window for ventilation of vapor was composed of straight lines. As most scenery of China is composed of majestic curves, this simple design composed of straight lines was fresh to me.

We parted Liu Tsai Pin who went back to Nanjing, and visited Guilin on the last day of our trip. We hiked from one stone mountain to the next. I was thinking of Japan and Uta. After I got back to Japan, I moved to the Tokyo Astronomical Observatory in November, but also held the post of Professor at the Department of Science until the end of March.

2.3

Our three mixed-blood daughters were gifted with the cuteness of Eurasians. When they were young, they were bullied with the word of 'half.' As they grew to adolescent ages, their rare existence of double bloods became to be evaluated highly. Uta and I did not feel bad for this. On New Year's day, we dressed them up in Japanese Kimonos that were available to us. Kimonos matched them well. But this was going to be the last New Year's day with such relaxed feelings.

At the end of March, I cleared out the office in the Department of Astronomy of the University of Tokyo. When I had moved into this office twelve years before, I bought a pot of a foliage plant at a flower shop in Nezu-town. After I cleared the desk from the plant that was creeping all over it, my clearing work was over. Ms. Taiko Motoki and Ms. Sachiko Isoda of the department office, who had known me since I was a student, were worrying if I could work with the observatory people knowing that I am a slovenly guy.

"Professor Kodaira, are you all right? Take care of your health. You keep yourself quite busy. That's not good."

Ms. Motoki had correctly guessed that I would suffer from mental strain more in the observatory than in the Department of Astronomy.

Her guess was right. From April on, I was chased by miscellaneous business as a professor of the observatory. The observatory was not like the Department of Astronomy where there are many students. Instead, it was a non-clerical government enterprise. Many people of the observatory were older than I. They were there since long time as if they were planted there, and they also knew more about the history of many things than I did. In the campus of the Tokyo Astronomical Observatory in Mitaka, there were old official residences for the night duties, and many staff lived there.

I visited the 'Mitaka Village' several times as a young boy and I worked there two or three years as a research assistant. But I found that there were many customary practices which were unknown to me before. Of course, some of them were good. But what I worried most was the lack of an intellectual atmosphere that observatories in Europe or in U.S.A. have. It seemed that the observatory in Mitaka was like an office doing astronomical enterprise.

From my house in Suginami, it took about equal time to go to the Department of Astronomy in Hongo and to the observatory in Mitaka. At the Department of Astronomy, I was in the office by ten o'clock while at the observatory at Mitaka, it was at nine. Most officers and technicians leave the office at five. In my house, the family ate breakfast and dinner together except for special occasions. So, it was no problem to go early because we lived according to our daughters' school hour schedule. But, I did not get used to the office-like atmosphere of the observatory for a long time.

I belonged to the Spectroscopic Division, and became a member of the Long Term Planning Committee, which is a committee beneath the faculty meeting. The Spectroscopic Division was in charge of observations of the Sun and stars from space, and had a laboratory for vacuum ultraviolet. It was the only laboratory in the observatory. I continued to study galaxies, while at the same time I was doing experiments with Wataru Tanaka of Hongo for the telescope for the stratospheric balloon observation and the telescope for ultraviolet observation to be launched by a rocket. As the professor of the Spectroscopic Division, I was expected to realize the ultraviolet satellite project (UVSAT), but this did not progress as I wanted it to. The budget for the ground observation goes through the Tokyo Astronomical Observatory. But the observation from space is done by the Institute of Space and Astronautical Sciences (ISAS). Because of this, for the Long Term Planning Committee of the Tokyo Astronomical Observatory to draw up the request of budget for the next large optical telescope was an urgent business. And I, as one of the professors in the main observational divisions, had to take some responsibility.

The plan of 'three meter telescope in Japan' made by the association of optical astronomers was thought by many people, as a 'result of compromise.' The plan consisted of making a telescope less than three meters in Japan and then making a two-meter class telescope at a good site abroad. Surreptitiously, I was determined to thoroughly study the possibility of building a large telescope abroad.

‘If the study shows that the plan is impossible, then I will give up. But I cannot give up without studying it thoroughly.’

I argued this way, but in my mind there was always the thought I had in the night train to Rome;

‘I will do what I wish to do the most. I may not reach the goal, but there’s no other way.’

One day, I dared to ask the members of the Long Term Planning Committee;

“Suppose that we are free from the conditions of budget and system. Then, don’t you think that we should build it abroad from academic reasoning only?”

“Yes, you are right,”

most people answered positively. I decided to study it thoroughly.

At such a time, I had a chance to be sitting next to a high-ranked officer[1] of the Ministry of Education, Science, and Culture (MESC). It was at a lunch party held by the ambassador of West Germany on occasion of an honored guest of DAAD. The master artist Kaii Higashiyama and officers of MESC of the related divisions were invited to the party. I waited until the lunch was over and the participants started to talk at ease with their neighbors, then asked him,

“Is it possible to build a telescope abroad, say in Hawaii?”

His answer was unexpectedly gentle;

“It may be possible provided that the observatory change its present status to a national institute.”

MESC had already made a decision that institutes affiliated to universities should be cut from universities and become institutes under the direct control of MESC in accordance with the administration reform discussed by the Special Committee for the Administration Reform of the Japanese Government. If an institute is not attached to a university but is under direct control of MESC, it is an institute for all the universities in Japan, namely, 'an inter-university research institute.' Such an institute can carry a national project.

'High Energy Institute' was already established in the Tsukuba University Town, and an accelerator project called 'Tristan' was going on. When accelerated particles collide with each other, high density and high energy states of space-time similar to the very early phase of the universe is realized for a brief instance. Elementary particle physics that probe into the nature of material and cosmology were closely related to each other. The high ranked officer of MESC might have had similar image on the relation between the observatory and the next telescope as the relation between High Energy Institute and Tristan.

We heard of the evaluation of the existing institutes under direct control of MESC and institutes affiliated to universities. We also heard,

"Tokyo Astronomical Observatory was evaluated so that it could go on, while the Latitude Observatory doing similar works was not."

The high ranked officer added casually,

"Latitude Observatory at Mizusawa should be included in the new national observatory."

I have been thinking through the plan to realize the project within the frame of the Tokyo Astronomical Observatory. But within the frame of a national institute, a large telescope abroad may be easier to be brought about.

It seemed to me that some clever people were discussing the matter at an unknown place. Later, I learned that 'Academic Council' existed and prominent figures in the Council made decisions on important matters. The high ranked officer did not forget to add,

"Each one has his own idea. Some are 'for' national institutes while others are 'against.' Among the MESC officers, too."

It was also at that time that I got acquainted with Diet members. For me, it happened accidentally. But it might have started from a talk on the telescope between Dr. Shuzo Isobe of the Tokyo Astronomical Observatory and a Diet member who happened to have been a fellow in the sports club in the university. He was Mr. Kaoru Yosano of the Liberal Democratic Party. He himself was an amateur astronomer and owned a 20-centimeter reflecting telescope. Mr. Yosano created a 'Group of Diet-members for Promotion of Large Telescope Project' with Kouichi Kato as its representative. Among the members were Mr. Motoo Shiina, Mr. Hajime Funada, Mr. Kosuke Hori, Mr. Tatuo Sasayama, and Ms. Hiroko Hayashi.

Dr. Isobe was enthusiastic to promote the new technology telescope, and was engaged in the study of 'honeycomb mirror' that the University of Arizona was developing. He sent a team to Arizona and helped their experiment. In Japan, he was making experiment and test casting in cooperation with a glass company.

'Honeycomb Mirror' is a mirror with structure of many vertical holes like honeycomb. It is as strong as a monolithic mirror, but its weight is by far less. A large mirror for a large telescope is distorted by its own weight. The history of mirrors of large telescopes was the conquest of this distortion and the fight against the thermal deformation caused by temperature change. In 'The Glass Giant of Palomer,' the book I read in my boyhood, the record of the fight by Dr. Hale, the founder of the Glass Giant, was written. The 200-inch mirror of Palomer was cast with many hexagonal holes on the backside. Honeycomb mirror advances the Palomer design and makes vertical hollows inside the mirror. Research was done on how to cast the molten glass into the complicated mold, then, after it was cooled down, to remove the hexagonal core out of the mirror. In order to cast into this fine mold, glass with small viscosity was required. A Japanese glass company had such glass.

'Which is better, a honeycomb mirror or a thin light weight mirror supported by computer controlled robot arms so that distortion by its own weight and thermal deformation can be compensated?'

I began to think that change of approach from the traditional rigid structure to a flexible thin structure might be necessary. Through my study of galaxies, I learned that heretofore-unimaginable calculations became feasible with the use of large electronic computers. Also, the technique to analyze the oscillation of the disc of galaxies seemed to me applicable to the mechanical analysis of the round thin mirror.

'Which should I take?'

I had to make a thorough study to answer this question. Dr. Isobe started to study the honeycomb method enthusiastically.

We attended a breakfast meeting of the 'Group of Diet-members for Promotion of Large Telescope Project' with the mirror structure problem in mind. At the meeting, however, the topic of the table was mirrors of sixteen meter or twenty five meter that European and American engineers think to be new large mirrors, and I felt the gap of understanding the problem between the members of the Group and us. I learned by listening to the talks of diet-members, however, in order to get funds for a large telescope, discussion among the researchers is not sufficient. A procedure twined around the system of national administration was necessary. Soon after this breakfast meeting, I knew the existence of diet-members called 'Diet Members with a Special Interest in Education.'

Breakfast meeting were held several times, but the Group never started to make political activity. Sometimes, a newspaper wrote about it in a small column. Then the director of the Tokyo Astronomical Observatory got angry with me. The reason was that I could not escape from being attacked with an argument:

'He is too superficial as a researcher.'

As I got acquainted with the diet-members during the breakfast meetings, some members of this Group of the diet-members helped me since that time.

---

[1] Hitoshi Osaki

2.4

In the summer of 1983, the year I moved completely to the Tokyo Astronomical

Observatory, my long cherished desire of observing in Hawaii was going to be realized. I applied for the fund created by the University of Tokyo as the commemoration of its one hundredth anniversary, and was allowed to visit Hawaii for ten days. As our family budget was quite reduced because Uta went to Germany to help her sick mother Johanna on vacations and I visited many countries, I appreciated this fund very much. This year, I made five trips, to Hawaii, Italy, United Kingdom, France, and Arizona, U.S.A., and Uta visited Germany three times.

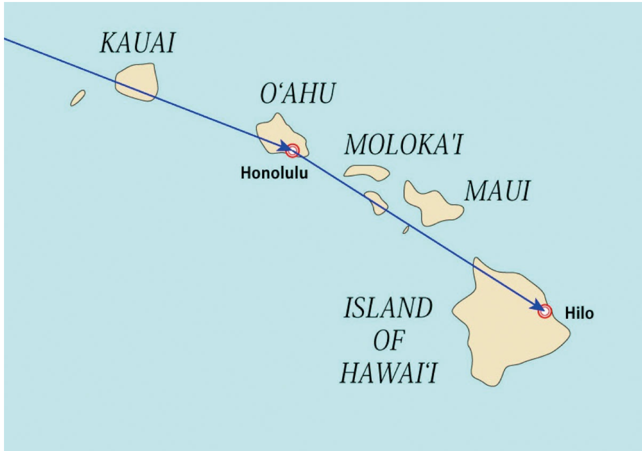
In Hawaii, I made infrared photometry of SS433, a star showing super-jet flows, as I tried at Calar Alto in Spain. I was allocated one week of 88-inch telescope of the University of Hawaii, and ten nights of sixty-centimeter telescope parallel to the main observation. As Dr. Koichi Nakada of the Department of Astronomy, the University of Tokyo, who was my team-mate in the balloon project, was at that time on the way back from the mainland, I asked him to make simultaneous observations in the optical light and in the infrared. The purpose of this trip was of course the observation. But another purpose which was equally to or more important than the observation was to make a study of observing conditions at Mauna Kea and survey the conditions for the construction in this international observatory.

The first day, I dropped in the Institute for Astronomy of the University of Hawaii in Honolulu, asked the director, Dr. Jefferies, about the conditions for construction, and reported him the status of our discussions in Japan. As I was very cautious to ‘building the telescope abroad,’ although I had made many surveys in foreign countries, several opposing people even said to me before my departure,

“We told astronomers in Hawaii that the construction in Hawaii is not realized because you do not decide.”

Dr. Jefferies, the director, explained again politely to me the conditions in detail, and taught me what I should be most careful about and the candidate sites available at that time on the summit. Talking with him, I forgot unfruitful discussions in Japan and felt to be melting into the large world of academic astronomy, and felt that Japan can easily be a member of the Mauna Kea society. The next day, I climbed up the mountain.

At Hale Pohaku 9,000 feet above the sea level, a fine dormitory for international use was completed. It was not there when I came here two years before. Four two-storied wooden buildings were built on the slope and were connected to each other by roofed corridors. Its design matched well with the natural scenery. Entering the building, I found a large and light dining hall. On the south side is an open lanai (balcony in Hawaiian) facing the majestic Mauna Loa. On the wall of the opposite side are hanged maps of the participating countries; United Kingdom, U.S.A., France, and Canada. A female astronomer with hairs un-brushed was taking late breakfast. Newspapers were scattering on tables. The counter of the kitchen was already closed.



Route of the site-survey trip to the Island of Hawaii.

Astronomers staying at Hale Pohaku, learning that Japan is studying the next telescope, joined discussion as if the project were their own. Actually, although the telescopes on the summit were of various size, because of good site, all of them were 'world first class telescopes.' Everybody coming here was a friend. In the dining room, exciting results of observation of the preceding night were talked about. Then, the discussion terminated into

"I will check it with my telescope tonight,"

or

"I will make spectroscopic observation next month."

It was in July. It was all right with the clothes I put on when I left Japan until I arrived at the Big Island, but it was cold while preparing the observation in the dome of the 24-inch telescope where wind blew through. My colleague Dr. Nakada was complaining headache since his arrival at Hawaii. On the fourth day, he got seriously sick. On the first day, we only made preparation. The second night we started observation, but he was low-spirited and was unlike the usual lively Dr. Nakada. He took aspirin but it didn't work. The third day, he did not have appetite. That night, I told him to stay at Hale Pohaku, but he came up to the telescope with me. However, he could not move as usual and was lying on the floor, or tried oxygen. At lunch time of the fourth day, he didn't eat anything and said,

"Something is rolling in my chest,"

with his face quite pale.

"This is bad. He may have gotten pulmonary edema. He is in an advanced stage of altitude sickness."

I persuaded him to go down, and got him in a vehicle and took him to the Hilo Hospital. He was surely in a state of advanced altitude sickness, and was hospitalized immediately. Altitude sickness is a serious illness. Tough guys like mountain climbers or test pilots often get this sickness. When discovered in an early stage, he will recover quickly if he goes down to lower altitude. If he works hard without going down, it may lead him to a serious state.

From that day my schedule was very tight; I observed at night alone, and the next day after lunch, I went down to the hospital to visit him, then followed dinner, and then observation. I gave up simultaneous observation with the sixty-centimeter telescope, and concentrated on the near infrared observation with the 88-inch telescope.

Dr. Nakada looked quite all right after one full day in the hospital and seemed to have recovered his appetite.

"I am O.K. now. As it costs a lot, I wish to be discharged from the hospital, but the doctor does not agree with it. Nurses are very kind to me, so it's comfortable here,"

was his sour grape. Eventually, I did the rest of observation by myself.

"What are you doing now?"

At the midnight of the sixth night came up Dr. Fujio Matsuda, the President of the University of Hawaii. Dr. Fujio Matsuda had a degree in engineering and was the first president of the University of Hawaii as an American of Japanese ancestral origin. He is not tall and a good-natured old man.

“I am measuring the variation of the infrared light of a star that is emitting a jet flow nearly close to the light speed.”

“Well, will you let me see it?”

Dr. Matsuda watched the white light spot dancing in the viewer of the guiding telescope.

“Is this the star you are observing?”

“Yes.”

“What does this serve you if you observe it?”

“I wish to know why such a star can emit jet flow at a speed close to that of light.”

“Can you make use of it for something?”

“No, not immediately.”

Dr. Matsuda seemed a little disappointed.

“Will Japan build a telescope here?”

“We are discussing about it. Dr. Jefferies is helping us to make our survey.”

Then, I realized that the person who guided the president and now standing behind him was Ms. Ginger Plasch, Secretary to the director for Mauna Kea Affairs. She drove a 4WD vehicle to guide the president by night. I guessed that Dr. Jefferies wanted that I meet the president at the summit. He said,

“I asked once in Japan if Japan is interested in Mauna Kea. At that time, I got a negative answer.”

I said at a breath,

“I wish to build it here. Please help me in the future.”

“I will do whatever you want if it helps you,”
with his hood of parka on his head, he answered slowly but clearly in English with some accent of Japanese origin, and went down the stairs of the dome.

That night it was clear. Before the dawn, I wanted to observe some star other than SS433. As I got the opportunity to observe in Hawaii, before I left Japan, I got an approximate position of the X-ray burster near the Galactic center obtained by the Japanese X-ray observation satellite. X-ray burster is an X-ray star whose X-ray intensity increases in a burst-like way from time to time. Generally speaking, a celestial object that is optically faint but emits strong X-ray is discovered as X-ray star. But the X-ray of a burster is usually weak, therefore it is difficult to measure the position. As the history of optical observation is quite long, if the corresponding optical object is identified, the information on the object increases all at once. However, as an X-ray telescope does not have as much resolution as an optical telescope has, it is difficult to find out an optical counterpart with the information on its position only. Most of the burster near the Galactic center were known to be within globular clusters. In a globular cluster, the stellar density is high, therefore probability of strange celestial object is high.

As it is very close to the Galaxy, the absorption by interstellar dust is large. That may make it invisible. If the globular cluster is hidden by interstellar dust, it may be found if searched in the infrared light which is less absorbed. Thinking this way, I got the data of the position of the burster from the X-ray team.

At that time, only one point in the sky was measured at one time in the infrared observation. We cannot find out the invisible X-ray star without a map of the distribution of infrared light which is made by shifting the telescope little by little to measure the infrared strength. If the shift is small, we cannot make a search of a wide area. Observation of X-ray satellite was made by Sudare collimator invented by Professor Minoru Oda, and the area in the sky where the X-ray star is expected to exist was drawn in a wide diamond shaped error box on my star chart. As it was not clear if I could observe the next day, I decided to make a search of a wide region first with relatively large grid points as planned beforehand.

Every time data for four wavelengths were printed out for each observational point, I waited the numbers on the printer holding my breath. When the telescope was directed to a point where a star exists on the star chart, the printer printed out large values. Meanwhile, a little past half the planned observation, the printer printed large values at a point where no star was found. Definitely this was something because all four wavelengths showed large values. I was wondering which decision I should make, to observe its vicinity in detail, or to continue the planned survey for the wide area. And I calculated its approximate position. Certainly, it was within the error box. The coordinate system used in the X-ray observation was based on the 1950.0 origin. Isn't there any error in my calculation? The present position of the telescope was calculated with a standard star of position near the error box.

"I will calculate it again tomorrow and check it."

Two or three faint infrared objects were observed during the rest of my observation, and the survey of the planned area was completed. I returned to the standard star for position close to the area and wrote down the right ascension and declination of the telescope. Dawn was close and twilight started. The moon was also bright. As infrared observation is not much affected by the scattered light of the Sun or the Moon, I returned again to the bright infrared object and observed its vicinity carefully. It seemed that the source is extended. But its altitude was already low and the atmospheric condition was not favorable. Therefore that may have been a blurred star image caused by bad seeing. Although I was still hesitating whether to continue or not, I gave up the survey and directed the telescope to a standard star for brightness and took data. A rough calculation showed that the candidate star is eight magnitudes in 2.2 micrometer band.

When observing an unknown celestial object, the principle of observation is to measure its position and brightness relative to near-by standard stars several times. Standard stars for which position and brightness are measured accurately are distributed all over the sky. When planning the observation, we picked up some of them before.

The next morning, I got up early. Tonight would be the last night for me with the 88-inch telescope. I opened my notebook on the small desk of my room in the Mid-level Facility. I calculated the brightness at each wavelength and of the relative position to the standard star from the data of X-ray star survey I did last night with the small electronic calculator that I kept in my pocket. It was simple addition and subtraction. But I got different results every time I repeated it. It might have been because of altitude, or because I could not sleep well, or because I got excited by the discovery. I got angry with myself. It was possible to interpret the difference of brightness at different wavelength if the globular cluster is dimmed by the interstellar absorption. But the absolute brightness may be too small for the value of absorption estimated from the brightness at four colors. The position was closer to the edge of the error box than that I calculated the night before. I could not judge if this infrared object was the same as the X-ray source. If it was a globular cluster, only the bright center would be observed, but it should be extended than a star. I could not say that the source surely was extended.

'Tonight, I will pursue the observation and see if it is extended or not.'

The last observation night was a clear photometric night. When the dawn was close, I directed the telescope to the spot of last night. There was the infrared object. I could not recognize it in the optical light. I made the aperture stop of the photometer as small as possible and scanned vertically and horizontally. It was a little wider than other stars, but was difficult to confirm it. Images of other stars in the optical light were worse than those in last night, and swelled and danced. As the altitude was low, the earth's atmosphere worked as a prism and a star looked as a rainbow. It became dawn as I repeated several trials.

Next morning, I got up early again and made the same calculation. I was not sure if it was the same object as the X-ray source. I could not say that it was an extended object either. That day, my schedule was to go down and visit the base facility of the Canada France Hawaii Telescope in Waimea to make a survey. After I made a copy of the field note of observation, I thought I should let other astronomers know of this object. When I prepared for check out and went to the hall of the dining room, a French observer has just arrived there. He suggested me, “Send a telex from the base facility to the IAU Bulletin.”

Waimea is located between the Hilo-side tropical jungle and the Kona side desert at a saddle point on the seaside road. Cool misty rain shrouded to mountain top. The base facility of Canada France Hawaii Telescope (CFHT) moved from a shabby rental house to a newly built office building with elegant French design. It was surrounded by Hawaiian flowers and green leaves. The shiny board of ‘CFHT’ at the gate of the roadway made the region bright. In the office, the director helped me immediately. “We detected an infrared object close to an X-ray source. It may be the central part of a globular cluster. Position is ⋯, Its magnitude ⋯” After I sent the telex, I regretted a little bit because the data were not good enough because of insufficient observation time.

The director of CFHT, Dr. Robert McLaren, taught me that the observatory was funded by three countries and is operated as a non-profit organization of the State of Hawaii, that the director and the associate director are appointed from Canada and France alternatively, that personnels other than the astronomers sent from the two countries are hired locally via the University of Hawaii, etc. He also told me their experience that a large telescope should be built at a site with good atmospheric conditions otherwise its light gathering power will not be used effectively, that it is better not to make too many observational instruments at first. The number of night in a year is limited. If there are too many instruments, it is not possible to use every instrument to its full possibility. It will turn out that only two or three instruments are used, and the other will stay in a storage room. He said,

“We still have some instruments sent to us but not used yet. They were fabricated according to the wish of the astronomers in France and Hawaii, but it needs hard work before it is used in daily operation.”

He also said,

“For an observational site such as Mauna Kea, you should prepare limited number of instruments as if you are launching them into the space.”

I was feeling that someday a Japanese office would be opened here.

Dr. Nakada came back to Tokyo quite recovered from the pulmonary edema. I almost could not believe that he got seriously sick during our observational trip. In Tokyo, a telex from an American X-ray astronomer who saw IAU Bulletin was waiting me.

“Let me confirm the error box of the infrared object you observed. It seems to me that the position is closer to another X-ray source.”

But the position was not consistent to each other, either.

2.5

In November of the same year, I went to Arizona to make survey of observatories. Dr. Roger Angel of the Lowell Observatory, the University of Arizona, was making experiments extensively for development of honeycomb mirror. He built a large glass casting factory in the space below the stands of the football stadium in collaboration with the Optical Research Center of the University of Arizona. He believed that the honeycomb method is the best way to make mirrors of future large telescopes. Low cost was the distinctive merit. He also thought that the temperature of the entire mirror could be controlled by the air-flow through the honeycomb hollows. The idea of the physicist Dr. Angel was superb and his project seemed to be going well. But he needed initial investment for the construction of the polishing factory. He invited Japan to join the joint development. To my regret, I could not answer positively.

In projects of Europe or U.S.A., developmental study is made first and several possibilities are tested. Quite an amount of money is spent on this. Sometimes, the cost amounts to one third of the total cost of the final instrument. This developmental study optimizes in both the cost and the engineering sides, resulting in the good final product. Contrary to this, in Japan, usually only a small amount of money is spent for developmental study before the total project is funded. No fund is given to a project without good prospect.

In Arizona, I visited the headquarter of the Kitt Peak National Observatory (KPNO) in the campus of the university, and learned the present status of the large telescope project of U.S.A. and the problems of operation of Cerro Tololo Pan American Observatory. Each observational instrument to be used in Cerro Tololo is made and checked in Arizona, then used at KPNO before it is sent there. When something goes wrong with it, repair is not done there and it is sent back here. Also dispatching staff of KPNO to Chile was a problem. Life in Chile, especially in La Serena, is harder than that in Arizona. So, with two years as a unit, they are dispatched in turn.

This National Observatory had a division of data analysis that occupied many rooms. Specialists of computer software were working on the processing of the image data. From now, electronic camera using semi-conductor light detector will be the mainstream of astronomical observation. Then enormous information is stored in electronic form in computers.

'The key point of research will be the speed and quality of processing electronic data. Japan is far behind U.S.A. in this field, We cannot get the fund for developmental study. A large telescope is far beyond our scope,'

I was at a loss thinking of our future work.

Engineers who worked on the three to four meter class telescopes in 1970s in U.S. had a project of sixteen meter telescope. It was a 'multi-mirror system' telescope that puts four eight-meter honeycomb mirrors on one mounting. In parallel to this, segmented-mirror-system was also studied by astronomers of California Institute of Technology. This uses many hexagonal mirrors of 1.5 meter size to make the mirror area equivalent to a ten-meter mirror. The merit of this system was that each mirror was small making it easy to handle. Its cost seemed to be much cheaper than the cost of an ordinary system. But the difficult problems with this system were polishing non axi-symmetric partial mirrors and the control system of the relative position of the segmented mirrors. On the multi-mirror system, combining the light from four telescopes was the hardest hurdle to be conquered. However, at the Mount Whipple Observatory in Arizona, Multiple Mirror Telescope (MMT) was already in operation. It was supported by the Smithsonian Institution. I heard that its six mirrors came from the Air Force. The biggest purpose of this survey coming to Arizona on my own expenses was to see observations with this MMT.

Some time before my departure, Professor Yasuro Tanaka of the Institute of Space Aeronautics and Sciences called me on the phone. He said,

"X-ray satellite discovered a new celestial object. Please identify the optical counterpart as soon as possible."

I took photograph with the 188 centimeter telescope at the Okayama Astrophysical Station and found a blue star at the same location as the X-ray star. I wanted to make spectroscopic observation to find out the nature of the star if I am allowed to use MMT. A telescope like MMT whose image quality is not good but which can gather a lot of light suits detailed study of faint stars. But telescope schedule was not arranged as I wished. The observation was not made during my stay, and my collaborator did it after my departure. After I returned to Japan, we analyzed data together. The star was a binary. A high-density star is rotating in an elliptical orbit around the main component star that blows out gas. As the two stars come close, gas accretes on the high-density star and emits X-ray.

During my stay, I could not get observation time, but I watched Dr. Jacque Becker, director of the Mt. Whipple Observatory, made 'speckle observation.' When light wave front is scattered by a rough surface, interference makes a fine pattern. Analysis of this 'speckle pattern' gives the surface figure. This technique is used to check the surface of metals. When light wave coming from a star is scattered by the inhomogeneity of air in the atmosphere, the same kind of phenomenon appears. As the inhomogeneity of the air changes with time, it is necessary to observe instantaneous speckle patterns. MMT with large effective diameter is capable to make this observation. When we get the information on the inhomogeneity of the air, we can get the information on the characteristics of the on-coming light wave, specially the intensity distribution of the light source. It is possible to distinguish a single star from double stars. Even if it is a single star, if it is a relatively close-by super-giant it is also possible to know the uniformity of the surface .

MMT was shining like a space station on a cliff of Mount Whipple. We drove a little while leaving the city of Tucson, filled in necessary forms at the office at the mountain foot, and climbed up the mountain road. MMT that carries six telescopes on one mounting has extremely short telescope tube for its aperture. Its dome is not semi-spherical. The design made by a young female architect was box-shaped with large opening. The building was innovative in that it rotates with the telescope. It certainly gave an impression of looking forward to the future. Looking at the building on this rocky hill will surely make the spectators think of the depth and width of the universe.

The director Dr. Becker said,

"Wind blows hard because the opening is large. Tonight, I plan to test the effect of the new wind shield,"

and directed the telescope to the windward. On the panel on the wall of the control room on the second floor of the right wing of the telescope, star images coming from the six telescopes were shown as well as the wind direction and the wind speed. Pushing a button inserts special mirrors in the light paths for composing the light and makes the images into one. It was recognized that the image was still vibrating because of the wind's breath.

"I plan to make windows for ventilation on the backside of this box building. We have heat wave because of the heat leaking from the rooms on both sides of the telescope. We made the effect of radiation smaller by covering the metal frame of the telescope with aluminum foil."

I understood that he was improving this experimental telescope system while obtaining various data.

“Don’t you have any inconvenience with the co-rotating building?”

“I have no problem as I am used to it. A cat living here seems to have trouble with it. We have a cat to get rid of rats. Oh, yes. I feel strange when I am using toilet.”

The director Dr. Becker was a frank man. He continued to talk as he obtained data for the telescope. It was an ‘engineering night’ for the director.

I was concerned about toothache. As my toothache got serious, I took aspirin and antibiotics. I usually carried medicine these days because my tooth nerves got sensitive due to hard works. The dormitory of MMT was like a cottage. The kitchen-dining room was self-service. The meal with only Dr. Becker was a little bit lonely.

This Mount Whipple Observatory has a large telescope called Fly’s Eye that catches faint light emitted when cosmic ray hit the earth’s atmosphere. It aims at the large light gathering power with many segmented mirrors. Mount Whipple Observatory is not a large observatory although it has a long tradition. But it challenges always the frontiers of astronomy, physics, and optical engineering with such an experimental instrument. It may have depended on the support of Smithsonian Institution that is a special organization under the immediate control of the President of U.S.A. I remembered the wonderful display of the Smithsonian Museum in Washington,D.C. United States has the National Observatory, observatory of California Institute of Technology supported by the Carnegie Foundation, and Institute of Astrophysics of the Smithsonian Institution. It has many more. It seemed to me that the difference of the size of the astronomical world between U.S. and Japan was enormous. I thought,

“Japan may have to build one to two meter class telescopes for universities.”

Dr. Becker sympathized with me and said with sandwich in his mouth,

“In order to bring up good astronomers, it is necessary to have telescopes that young people can use freely.”

2.6

It was about that time that the first space walk was done. From the hatch of the spacecraft slowly came out an astronaut and softly floated in the space.

One day in February around the first day of spring, Professor Minoru Oda, director of ISAS, called me on the phone. He talked in his gentle voice as usual,

"I am going to meet a MESC personnel this evening. Won't you come together? It may be possible that you can talk to him about the telescope."

"I would gladly come with you."

It was after dark that we met in a small room in the MESC building. Professor Oda was with the Director of the Admin Division of ISAS.

"I came here to talk about the space station. It's not an official meeting. If you are lucky, they may listen to your talk, too,"

he said moderately. There were three MESC officers. They were introduced as the chief of the Section of Research Institutes, a coordination officer with a beard, and the head of the subsection in charge.

"National Aeronautics and Space Agency (NASA) of the United States is promoting a project of a space station. They wish to do it with international coordination."

Professor Oda explained the outline of the project of the space station; to launch large structures into an earth-bound orbit and build a space base station so that an artificial satellite can be sent to the moon from there and that the persons living there can make scientific experiments and observations. The chief of the subsection took memos.

"They wish that Japan participates in this project. There are various ways of participation. This is worth studying. I think NASA will soon sound your opinion."

This was the main theme of the meeting of that day. He seemed to have finished his business of transmitting this unofficial information and it was agreed that the matter will be discussed later. When I thought that we were leaving, Professor Oda said,

"Can he explain the telescope project to you?"

The chief officer, probably previously noticed, nodded with an air of ‘There is no other choice.’

I did not wish to lose this opportunity and I talked in one breath the outline of the project that I repeated in my mind many times making the explanation as simple as possible. I talked first that I wished to see through the edge of the universe. Then I talked that I needed a large telescope at a good site for that purpose, that I believe that Mauna Kea in Hawaii is the best site judging from the result of survey, that the land is owned by the State of Hawaii, is in charge of the University of Hawaii, that the telescope should be larger than five meter diameter, that means it should supersede the giant telescope of Palomar, that the society of astronomy in Japan discussed the matter for more than five years and reached a consensus to materialize this project, that the construction would take six years and its cost would be thirty billion yen. I tried not to go into detail. Professor Oda did not intervene a word. When I finished, I realized it took one full hour.

“Oh! That’s an ambitious plan!”

the chief officer said and seemed to be relaxed after my long explanation. Professor Oda still remained silent.

“How is it in foreign countries? Do they have similar projects?”

asked the coordinate officer with a beard[2]. At least, this coordinate officer with a beard seemed to be interested while the chief officer kept straight face.

“Yes, they have such projects. In Europe or in U.S., they even talk about sixteen meter or twenty five meter diameter telescope.”

“Well, is it possible to make such a large one?”

“It is still being studied. Japan wish to have five meter at least, but we are also studying seven-and-a-half-meter mirror corresponding to 300-inches.”

After I finished my explanation, I thought,

‘I may have talked too much.’

“Thank you very much for listening to his explanation. Today, we have to leave now.”

Professor Oda thanked them. The director of the Admin division of ISAS had left the room while I was unaware of that. On the way back, Professor Oda casually remarked,

“You may get it as a gift when the observatory is shifted as a national institute.”

Some researchers thought that it is a national project to build a large telescope abroad, therefore the observatory should leave the University of Tokyo to become a national institute. However, the short remark of Professor Oda sounded to me as if he was saying that the shift to a national institute is the major premise and the telescope is a something attached to it.

Those days, every time I met Professor Oda, I used to ask him shamelessly,

“Professor Oda, please do something for the large telescope project of Hawaii.”

That night I did not wish to ask him more because I was satisfied with the fact that, although in an unofficial meeting, MESC officers in charge listened to my explanation. I was also afraid that I am disappointed learning more. It was true that both the chief and the coordinate officer spent almost an hour listening to my talk and never showed a look that it was out of question. The coordinate officer even seemed to be interested with the project. It may happen that the possibility is not zero.

Thinking of the talk of the high ranked officer of MESC to whom I happened to sit next in the German Embassy last year and of the response of the MESC officers today, I thought that a study of shifting the observatory to a national institution is done somewhere unknown to me. Then, MESC may be thinking of a large telescope abroad ‘as a gift’ of the shift although its logic is the reverse to ours. I was encouraged very much. I decided in my mind,

‘I will do it thoroughly with the construction of a 7.5 meter telescope abroad as the target.’

For several years I was worried about what I should do, but I was feeling well with this thought. I became able to talk frankly to Uta about the telescope project. Uta was glad to hear my decision, but said to me worrying my health,

"But be sure not to overwork. You are tired these days."

It was true that I was talking less in the family. I went abroad often to make survey of the telescope site. In such a trip, I had to work hard and had to take care of many things. After the trip, I felt sleepy very much.

I made the same talk as I did at MESC at a breakfast meeting of the 'Group of Diet-members for Promotion of Large Telescope Project.' I compressed the talk into fifteen minutes although it took one hour at MESC. Listeners were the people occupied by the issues directly connected with the busy world. The Diet-members were not at all frightened by the amount of thirty billion yen. But this is an extraordinary amount for astronomers. The fund of the Nobeyama Cosmic Radio Observatory of the Tokyo Astronomical Observatory completed recently was ten billion yen. In the world of astronomy, this was an amount unheard of in the past. Diet-members were talking,

"The amount does not sound excessively large. But it may not be this or the next year to start it. A few years may be necessary for preparation."

I interpreted their talk as

"It is an interesting project but we do not know when it starts."

There may be other large projects in the field of science that competes ours in the fund-getting race. I thought that there is no way other than to make the listeners think,

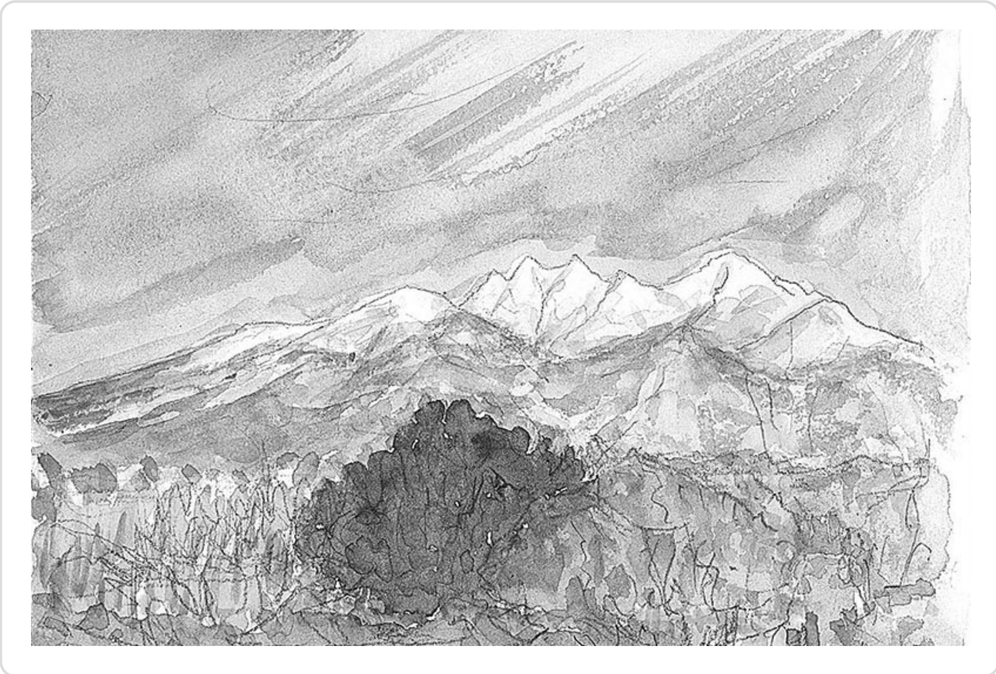
'We wish to have it immediately.'

---

[2]Katsuhide Kusahara

Chapter 3

Challenge to the High-Tech Engineering



3.1

Based on the discussion at the Committee for the Planning, the Tokyo Astronomical Observatory (TAO) officially decided to start the 'Survey' for construction of the large telescope abroad.

Since the time when astronomers started to discuss the next telescope, a meeting for informal discussions on optics and astronomy was organized and various subjects on telescope construction were studied. Dr. Tsugio Kono, of the Mechanical Engineering Laboratory, Institute of the Ministry of International Trade and Industry (MITI), chaired the meeting. Other members included specialists of optics, optical designs, and researchers of astronomy. The meeting was held approximately once a month. It was a small group of about ten people. Sometimes, we studied the large telescope projects in U.S.A. or in Europe, sometimes the topic was about specific fundamental engineering such as structural design or glass material. But, since the

Japanese telescope project was not finalized, it was at a level of 'studying' rather than the survey for the project. Parallel to this, I personally did my survey abroad.

When I was nominated the General Manager of the Large Telescope Project Office of the TAO, I selected three people of different abilities, Kyoji Nariai, Hiroyasu Ando, and Takeshi Noguchi. I asked them,

"Please be ready to work together with me in the survey of the project of construction abroad."

It was very painful for me to ask them to do something that may turn out to be unfruitful because each of them had their own work they devoted themselves to at the time.

Dr. Nariai was one year younger than I and was specialized in stellar physics. He had an enterprising spirit and always followed through with a thorough job once he started on something. He had the ability to complete it. He lost his left hand at the elbow when young, but had a challenging spirit to do every sport such as skiing and swimming. He often boasted that he graduated from the Alpine Club (sangakubu) rather than from the Department of Science (rigakubu). He was one of the most reliable people in the team project. He spoke many languages, had many hobbies, and had many friends.

Dr. Ando belonged to a younger generation and used to be a student I supervised. He was steady although he was young, and was strong as a samurai. His specialty was also stellar physics. He was one of the members of the 'construction abroad' group since he was a graduate student. As a senior member of the group, I have been worried about the dilemma of telling him not to be too far ahead, and at the same time not to quench the firing spirit inside him. As the situation progressed, I believed that he would be with me to the end.

Mr. Noguchi, the third person I selected, was the most experienced in the construction of an optical telescope among the middle standing technical staff of the TAO. He worked at the Okayama Astrophysical Observatory at the starting time of the 188-cm telescope, then moved to Kiso Observatory to start and operate its Schmidt telescope. He knew much about the contract business. He was quiet and self-assured. I loved to see him drinking Sake alone in silence, what might symbolize his steady mentality. I thought that he would endure the upcoming long struggle of the telescope construction.

Although TAO officially started to study the construction abroad, the situation did not change much. However, some people who had stayed abroad for a while and came back, got angry and said,

“When did you decide this. It’s a coup d’état.”

Many people told me,

“It’s wonderful if we have a telescope abroad. I will help you as much as I can.”

But not many people actually threw away their own work and plunged into this turmoil. Most of them were suspicious of what would be achieved. Professor Yamashita who worked at Mitaka was also the director of Okayama Astrophysical Observatory. Since he was a little older than me, he could not lead the project whose date of completion would certainly come after his mandatory retirement. He, however, was the most reliable person in promoting the basic study and survey of the project. Professor Kozai helped me using his status of the director of TAO.

As the General Manager of the Large Telescope Project, I shifted the weight of my entire life to the promotion of the large telescope project. But I could not throw away the study of galaxies. I wished to have a large telescope because I wanted to study galaxies.

105 cm Schmidt Telescope of the Kiso Observatory.
©Kiso Observatory (Institute of Astronomy, School of Science, The University of Tokyo)

In order to prove that my zeal of research is fresh, I could not cut out my study of galaxies. Dr. Sadanori Okamura of Kiso Observatory and I, applied for the 'Research Fund for Special Promotion' and continued the study of 'quantitative analysis of galaxies.' We aimed at establishing an objective and quantitative classification of galaxies measuring the 'surface brightness,' while formerly the classification of galaxies was done by the apparent figures. It was not easy to make other people think,

'They are doing something interesting. Let him have a telescope.'

It put on me a burden of writing at least three research papers per year. Dr. Okamura was a good partner in this respect. Drs. Masaaki Watanabe and Shin-ichi Ichikawa were also good cooperators. I went to international conferences held abroad several times to present the results of these researches. On such occasions, I always had something to study on the construction of the telescope.

Soon after TAO officially decided to start survey, I started to write a draft of the 'Memorandum Of Understanding' (MOU) that will be executed by the University of Hawaii (UH) and TAO. It said,

"TAO has an intention of building a large telescope on Mauna Kea. UH welcomes this and cooperates. If the fund is secured by TAO and both parties can reach an agreement to the benefits of both parties, UH is ready to sublease the land required. …"

MOU was executed by me, the General Manager of the project, and Professor Kozai, the director of TAO, and on the Hawaii side by Dr. Donald Hall who recently became the director of Institute for Astronomy (IfA) and Dr. Simon, the new chancellor of UH. I reported this MOU issue to the Division of Research Institution of MESC immediately. I explained them that MOU does not bind TAO to build the telescope, but states the intentions of the both parties. It was in June of 1984, that I went to Hawaii for the first negotiation of the draft. After that, I frequently made visits to Hawaii, at least two or three times a year. Some years I had to visit Hawaii four or five times.

In July, Professor Kozai, Director of TAO, and I visited Professor Wataru Mori, an assist from a science course to the President of the University of Tokyo. We wanted that he understand the MOU between TAO and UH. Hearing our talk, Professor Mori said to our surprise,

“That is a wonderful project. Why don’t you do it as TAO remaining as an affiliate institute to the University of Tokyo.”

This was a very good proposal on one hand, and yet may create a very complicated situation on the other. Even at the time when Nobeyama Radio Astronomical Observatory (NRO) was created, we heard complaints within the University,

“Because of such a large facility, other field cannot get a sufficient budget.”

NRO is a common use facility for all the universities in Japan, therefore its operation is said to be very difficult. A large telescope in Hawaii will have more problems than NRO. With these thoughts in mind, I judged that realizing a telescope within the framework of the university is delicate.

At the beginning of the Asia Pacific Regional Meeting of the International Astronomical Union (IAU) held in autumn in Kyoto, the Japan National Large Telescope (JNLT) Project was introduced. And Dr. Donald Hall, Director of the Institute for Astronomy of the University of Hawaii who attended the meeting from Hawaii, made a lecture to support the project and to promise cooperation. That evening, Professor Tomokazu Kogure, who was the chair for the operation committee of the ‘Group of Optical and Infrared Astronomers’, Professor Kozai, Director of TAO, and Director Hall dined together and confirmed the meaning of the draft of MOU, and promised to promote the JNLT Project from that time on. ‘JNLT’ Project that started survey work in TAO was thus becoming a national project. Reflecting this situation, the Committee of Astronomical Research of the Science Council of Japan made a recommendation to ‘Construct an optical and infrared telescope with aperture larger than five meters.’

In the observatory, the Meeting for Engineering Investigation replaced the Meeting for Informal Discussions on Optics and Astronomy, and we were working for the definite target of constructing a 7.5 meter telescope in Hawaii [1]. Staff of the Faculty of Engineering and related institutes of the University of Tokyo and engineers of companies joined the meeting and we continued the investigation of the telescope. Based on the study of the meeting for informal discussions on optics and astronomy, we decided to make the general survey of construction of a large telescope. We sent out letters by the name of JNLT Project Room of the Tokyo Astronomical Observatory, to all the renowned companies in this field.

"Are you interested in this Project? In which part do you think you can contribute to the project? Do you have any practical proposal?"

Answers to these questions were the informations we wanted. Of course, we included Japanese companies in the survey. I was tempted to an idea of making the telescope only with the engineering of Japan. But I also thought.

'It may be impossible.'

As the largest mirror made in Japan was 1.5 meter in diameter, we had to face engineering breakthrough for JNLT, which surely would be one hundred times more difficult than the engineering problem they solved in the past. Although TAO officially started the survey and the meeting for informal discussions on optics and astronomy was supporting it, only three or four people worked full time on it. I kept on telling myself,

"Be patient."

One day, Ms. Motoki of the Department of Astronomy, University of Tokyo asked me,

"Professor Kodaira, you look so busy and tired these days. Why don't you hire a secretary to help you?"

She probably noticed that I was pressed by the load of work to be done. Before she had asked me the question, I did not think of hiring a secretary for myself.

‘If a secretary works for me, the person would be of a great help to me. But will there be a person who would work as the secretary in helping with the promotion of the telescope project? If there is such a person, how can I hire the person?’

I could not figure out how to do it. Ms. Motoki who had much experience in the administrative section, told me,

“You can hire the person as an administrative assistant. I can try to find someone who fits the job.”

She explained to me that I, as the Chief of the Division of Spectroscopy, was able to hire a person with the general budget of the division.

A few days later, Ms. Motoki called me on the phone and suggested Mrs. Tei Masuyama as a candidate. She was the daughter of Professor Takewaki of the Department of Zoology of the University of Tokyo, and worked for Professor Takeo Hatanaka of the Department of Astronomy after she had finished her undergraduate course at the Tokyo Women’s Christian University. I was in Germany during that period, so I had not met her before. I got her answer of

“I can come to TAO three or four days a week. Since my children are old enough, they do not need me all the time.”

I thought I could rely on Ms. Motoki’s evaluation. She knew me since I was an undergraduate student of the Department of Astronomy. So, she must have explained to Mrs. Masuyama that I am not a methodical person. I felt something supernatural in that she was a secretary to Professor Hatanaka. Professor Hatanaka was the leader of the group of space observation from outside the earth’s atmosphere at its initiation phase. He had also promoted the Large Cosmic Radio Telescope Project. He passed away before it was realized and many astronomers missed him very much. I remember the day when Professor Hatanaka surprised me by asking,

“What do you think?”

It was in a Meeting where Professor Hatanaka was the chair and he was asking the professors to present their opinions on the subject. As I was a novice in the postgraduate course, I did not expect that he would request my opinion, but he asked me the same question he had made to the senior attendees. Such was what I remembered of Professor Hatanaka. I thought,

‘She who worked for Professor Hatanaka as a secretary must be an able person.’

She came to my office with short-cut hair and in beige blouse and a moss-green tight skirt. She had an atmosphere of a calm young woman. As I expected, she soon became an indispensable member of the project room.

That year, I visited the Byurakan Observatory in Armenia. It was a part of my survey. The Soviet Union had just completed a six-meter telescope in the mountains of Caucasus. Dr. Shiro Nishimura had already visited this observatory. The telescope itself was a very ambitious one, but either the polishing or the support of the six-meter mirror was not good enough and its resolution was not as good as they expected it to be. The six-meter mirror was replaced with a new one, but it did not work out well. The six-meter telescope was installed at a height of one thousand and five hundred meters above the sea level. This height is almost comparable to Mount Palomar where the five-meter glass giant was built. A photograph of the dome shows trees growing in the surroundings. I thought that the atmospheric condition was inferior to that of Hawaii, Chile, and the Canary Islands whose heights were above two thousand meters. I could not visit Zelenchukskaya where the six-meter telescope was located, but I decided to visit the Byurakan Observatory in Armenia, which is built at a similar environment as the former.

Armenia is a small country at the edge of the Soviet Union. It is a country with its own Christian Church and has a rich cultural tradition. When seen from the Middle East Asia, it is located in the upper stream of the Tigris and Euphrates. The country is full of remains of the ancient civilization. Mount Arafat with a legend of Noah’s Ark is close.

The Byurakan Observatory was famous in the Soviet Union for its observational research of galaxies. Dr. Ambartsumian, director of the observatory, was known by his scientific philosophy,

‘Energy is produced at singular points of the space-time of the universe.’

According to him, such a singular point exists at places like the center of galaxies, from where child galaxies and grandchild galaxies are ejected. He was trying to establish its observational evidences by studying peculiar galaxies. He and his colleagues had similar ideas on stars. Explosive events at the surface of stars known as flares were explained to occur when large energy is released from a singular region inside stars. All the researchers of the Byurakan Observatory were working observationally with this working hypothesis. But they did not explain the true nature or physics of the singular points, and depended upon the difficult scientific philosophy of Ambartsumian. Observation was important here. The two-meter telescope and a Schmidt telescope were working. The campus of the observatory headquarters at the foot of mountain was large. Big buildings were scattered in it. The apartments of the staff were close by. When I was invited by Dr. Oskanian, with whom I got acquainted with at an international conference, while drinking the famous Armenian Cognac, I could hear conversations on politics such as

“Although we are in the Soviet Union because there is no other solution, we do not like Soviet Union,”

and

“If we are not in the Soviet Union, Turkey will come to occupy the land. This is worse.”

I thought that the Communism scheme didn’t work well. Dr. Oskanian winked to me when someone said,

“Local calls are free. Therefore, it is impossible to make an urgent call because ladies’ chats occupy the entire lines. Lines are not so numerous here as to allow urgent calls.”

---

[1] The telescopes of Mt. Wilson has a 100-inch (2.5 meter) mirror. The telescope of Mt. Palomar has a 200-inch (5 meter) mirror. So, we first aimed at a 300-inch (7.5 meter) mirror. Finally, it ended up with a 8.2 meter mirror of the Subaru Telescope in 1998.

3.2

Last year (1984), I made a general survey of companies capable of making a big telescope and its essential parts. This year (1985), I started another detailed survey of the companies who responded positively in my last survey. In July, I visited Corning Glass Works and Contraves in the U.S.A. During the past few years, I was visiting telescope sites all over the world looking for the best site for our large telescope. Then, I had to make many trips to make the worldwide survey of companies for the project. Uta and our daughters knew that my trips were indispensable for the birth of the telescope. Because of all my trips that were made abroad, my family was forced to live on a reduced budget, but they did not try to persuade me to live a more quiet life.

Two steps are necessary in the making of the mirror of a reflecting telescope. First, a glass blank with an approximate final shape is cast. A glass company does this work. Next, it is polished so that the final mirror surface is obtained. A polishing company, which is usually different from the glass company, takes over the job.

Since the time of Galileo, astronomers' dream of wanting to observe farther and fainter celestial objects stimulated the construction of larger telescopes, which meant making larger lenses and mirrors. The lens, as light passes through it, must be made of good optical glass. Moreover, because of the convex shape of an objective lens, its central part is thick and the peripheral part is thin. And it is this thin part where the whole weight of the lens is supported. Therefore, it is difficult to make a large objective lens, and its maximum diameter is limited to approximately one meter. The main mirror of a reflecting telescope is a convex reflecting mirror. It can be supported over the entire area from the backside. Light does not pass through the mirror material because the thin metal film on the front surface reflects it. This means that only the polished surface needs to be optically good. Because of these merits, all the large telescopes in the world made of monolithic glass are reflectors. Metal mirrors were used as reflectors in the old times (of Herschel). But ordinary glass is in an amorphous state without internal structure, like solidified candy, and not only allows light pass through within but also allows high precision polishing, and is most appropriate for a reflecting telescope.

Mirrors of large reflecting telescopes have two problems, i.e., ‘deformation by its own weight’ and ‘deformation by change of temperature’. These problems do not appear for large mirrors used in laboratories. As an astronomical telescope is directed to various part of the sky, the mirror changes its posture. In other words, the direction of gravity relative to the mirror changes. Then, the mirror deforms because of its own weight, and its surface figure polished to the desired shape changes. As the mirror handles the light wave, deformation of one tenth of its wavelength, i.e. 0.0001 millimeter, makes images bad. The ordinary solution to make the deformation caused by the change of direction small is to make the mirror thick. If the mirror’s thickness is one sixth of its diameter, supports at its back and edge keep the mirror surface as desired. However, if a large mirror whose diameter is larger than five meters has that thickness, its weight is extra-heavy, consequently, the entire telescope structure that supports the mirror becomes gigantic. It is necessary to use a light weight mirror with a clever support system. The segmented mirror system (used by Keck) needs tremendous study for the support system of the component mirror elements so that all of them move in conformity with each other.

During observation, the mirror of a telescope is exposed to the ambient air. This causes change of temperature distribution in the mirror, consequently, thermal expansion (or contraction) is not homogeneous in the mirror. This results in thermal deformation. In order to make this effect as small as possible, glass material with a small coefficient of thermal expansion (abbreviated as CTE hereafter) was investigated. Such investigation and research is useful not only for astronomical telescopes but also for all glass instruments used in an environment with large temperature changes, such as kitchenware for ovens, containers for chemical reactions, window material for space shuttles, etc. Breakage occurs when the internal stress caused by the expansion and contraction by temperature change rises above the limiting value. The temperature range for telescope mirrors does not go beyond the range of 20 degrees centigrade below zero to 30 degrees (from -4 to 86 degrees Fahrenheit), therefore Pyrex mirrors won't break. However, Pyrex changes its size by 1/10000 when temperature changes from boiling point of water to the freezing point; that means 0.01mm of deformation per 1m. Although the temperature change a mirror experiences is small, it is still not ideal for an astronomical telescope. Glass materials whose CTE is ten times less than that of Pyrex already existed. Ultra-low-expansion glass material! This small CTE is achieved by two methods. Corning Glass Works in U.S.A. uses a chemical method of mixing Titanium Oxide and Silicon Oxide, and Schott Glaswerke in Germany uses physical methods of creating micro-sized crystal-like structure in the amorphous glass medium. Amorphous glass of Silicon Oxide expands as the temperature rises. When the amount of Titanium Oxide becomes large, the mixture reacts the other way for a certain temperature range. Micro-crystal structures in the amorphous glass, grown by the control of the cooling process, also have negative thermal expansion effects. It became clear that both are attractive materials whose contractions from temperature changes of boiling point of water to icing point is one millionth. The decision for which glass should be used for our mirror seemed very difficult to me.

There is a completely different way of solving the thermal deformation problem. CTE of metal is large. It is more than ten times that of Pyrex. However, metal is known by its good conductivity of heat, which allows the temperature distribution to be controlled by the outside source. We may have homogeneous temperature throughout the mirror. If its material is homogeneous, its expansion and contraction may not change its figure much because the change caused by temperature change is homogeneous. So, it is not that the harm caused by temperature change is null, but it is easy to get rid of it. Beryllium mirrors and Carbon Silicate mirrors have already been fabricated, but they were very expensive. Polishing a large area was also a problem for metal mirrors, and a mirror larger than one meter was thought to be impossible to polish.

The fact that the amount of thermal expansion or contraction is small is a large merit during the polishing process. Polishing is, in principle, rubbing and abrading, so the polished material is heated. When measuring the polished surface, laser light is used to make interference fringes. Thermal deformation and the shimmering of the air above the mirror surface make the measurements unusable. It is absolutely necessary to cool the mirror rapidly to measure its surface. With ultra low expansion material, the mirror can be cooled down without special care, therefore, the polishing process of abrade and measure, measure and abrade can be shortened.

I flew to Corning, New York, in July, during the hottest time of the summer. The small city of Corning is said to have developed there because of the convenience of transporting firewood to be burnt in the furnace of the glass factory, and is supported primarily by this glass company.

Near the buildings of factories and offices, there is one short main street, which is sandwiched between two storied houses. Most stores sell merchandise related to Corning Glass Works. Some of them are stores run by retired Corning ex-employees. At the end of the street, there is a small plaza where Jazz concerts are held in the evenings. The old buildings with red bricks were still there and two or three old chimneys without any smoke being given out were there also. On the other side of the river lies the new commercial area. Modern buildings covered with glass windows were there. Corning Hilton was the only hotel running and offering places to stay overnight for tourists from New York City to Niagara Falls.

Engineers of Corning Glass Works welcomed me to discuss the work. Corning Glass Work is known to have produced the mirror blank of 200-inches for the Palomar Mountain. I read ‘The Glass Giant of Palomar’ before I had left Tokyo. I read the book once when I was in high school. I lost the very copy I had read when I was young. The copy I just read was one of the several copies Dr. Kyoji Nariai brought to our Observatory from the translator of the book he had somehow located just after the start of the project. I was told that the 200-inch mirror blank was made before World War II and all the engineers of that era were retired. One of the buildings at the other side of the river was used as a ‘Glass Museum.’ The first casting of the 200-inch disk which turned to be a failure was shown inside. Three engineers and one sales personnel who gathered together for my survey said unanimously,

"We wish to challenge the 300-inch disk."

I asked them,

"You had a lot of trouble with the 200-inch disk of Palomar. How do you plan to make a disk of a 300-inch size? I am thinking of a thin disk."

A big man, who seemed to be the chief engineer, responded immediately.

"That's it. That is the point."

The room we were in was not quite large. Five people surrounded a wide working table covered with many data sheets. It was somewhat suffocating. The room was in an old building that had a small window, and the air-conditioning was not so good. I drank many cups of coffee in order to stay awake as I was suffering from a jet lag. When the engineers spoke with enthusiasm, they spoke very rapidly, which made their English harder to understand.

"We can make a large monolithic blank by fusing together many ULE blanks of one meter size."

"Are you sure of the fused boundaries?"

"We have already done a four-meter class blank. Therefore, we do not see any difficulty for a larger blank."

Having said this, he brought in a fused sample from another room. I recognized the transparent boundary surface marginally scattered light at the mid-plane of a somewhat beige colored quadratic block.

"We do not see that this fused part is especially weak even if we break it by dropping it."

"What happens where the fused part comes to the surface?"

"When observed with a microscope, small bubbles are found on the boundary surface, but there is no problem when polished. Look at this surface through the microscope. Even if bubbles come to the polished surface, you can neglect that portion because its area is small compared to the entire mirror."

He referred to many digit numbers but I could not write them down in my notebook. At his words,

"You can bring our sample back to Japan if you wish,"

I gladly received the offer.

Next morning, I studied my notebook and data so that I can get most from the meeting in the afternoon. Two engineers attended the meeting.

"I prepared a drawing."

A drawing of a size of an entire newspaper spread was put on the table. It showed a large circle filled with hexagons, like turtleshells. Approximately thirty turtleshells were there, and at the periphery, they were cut to make a complete circle.

"The method used for a four-meter class mirror was applied to a 300-inch,"

he said.

"How much will be its thickness?"

I asked. He answered,

"A boule from which the hex is made, is 1.5 meters in diameter and it is twenty centimeters thick. Grinding a boule, we end up with a hex of ten or fifteen centimeters thick."

"Ten centimeters thick for a 300-inch disk? Does it not break? How do you plan to move it?"

I asked many questions.

"That's the problem. The actual work is difficult with a four-meter mirror if the thickness is less than twenty centimeter. We will challenge the twenty centimeter thickness with the 300-inch disk."

He put a large slide-rule on a white part of the drawing paper and quickly made a side plan. The cross section was a very thin plate with a diameter versus the thickness ratio of forty to one.

"It's quite thin. Given the same thickness, the bend is proportional to the diameter to the third."

This is an application of the theory of elastic body.

"We have to be almost ten times more careful compared to the four meter mirror."

"Then, the distance between support points should be smaller."

"How about this?"

On the turtleshells, he superposed grids. Then he drew circles at the intersections.

"We need support points between two hundred and three hundred."

"Do we need so many supports?"

I recalled the ten or so supports on the back of the 188-cm mirror at the Okayama Astrophysical Observatory. The thickness of that mirror may have been around thirty centimeters.

"Can you make a fast mirror of an aperture ratio of two, with such a thin blank?"

In our preliminary study, the main mirror had the aperture ratio of 2.0. That means, the focal length is 15 meters for a 300-inch parabolic main mirror. It was necessary to make the telescope with such a small aperture ratio and short focal length, otherwise the entire telescope as well as the dome will become gigantic. The main mirrors of telescopes of three to four meter class built in the 1970s, had a focal ratio between 3 and 3.5. We have to make the focal ratio smaller than theirs and keep the telescope and dome within reasonable sizes. A mirror of 300-inches with a focal ratio of 2.0! It means that the surface at the central point is thirty centimeters below the edge. It resembled the shape of a cover glass of an enormous watch, or what you might otherwise call as a meniscus shape.

"Yes, we can do it. First, we make a thin blank. Then, we put it in a furnace with a convex mold corresponding to the focal ratio of 2.0, and heat it. Then the blank softens and sags down resulting in a convex mirror blank with a constant thickness."

“Tell me. How do you put it on the mold? How much heat is applied? How do you take it out of the furnace?”

“We have to study these tasks. I do not think it is impossible.”

This was the start of a long, long study of glass.

Schott Glaswerke makes glass blanks of between 40 and 50 centimeters first, then cuts a thin convex mirror blank out of it. In casting, the furnace is rotated as the Arizona University does with its honeycomb mirror. The surface of the melted glass liquid forms a paraboloid as the gravity and the centrifugal force balance. The cooling of the mirror is done in this rotating furnace. This method was also an attractive and ambitious one with many developing elements.

3.3

While I was making surveys of companies, Professor Yamashita and Dr. Nariai were studying the optical design of the telescope. Professor Yamashita had basic knowledge of optics. But a large telescope of this size with small focal ratio cannot be handled with basic knowledge only. They decided to study optical design from its basics, visited the authority of optical design in Japan and were apprenticed to him. After many private lessons, Dr. Nariai succeeded to develop his own optical design program. I think that his experience of developing computer programs on the ‘structure of stellar atmosphere’ contributed to his success.

Professor Yamashita studied problem of bending of mirror material and telescope structure from its basics. Even if the mirror is perfect, the telescope will not work well if the telescope structure bends and warps. Expansion due to the temperature change causes the shift of the focal plane. A graduate student Dr. Masaaki Watanabe was a powerful member in this study group. Dr. Watanabe was a calm man and was a kind of genius. He had splendid sense of abstractive geometry. To him, ‘Rubik’s Cube’ was as easy as pie. In the study of structure of galaxies that was run with the Research Fund for Special Promotion, he developed computer programs and made considerable amount of calculation, and extracted the essence of the results quickly. He ran the program of 'finite element analysis (FEM)' and showed the deformations of the telescope structure and the mirror. FEM is a computer program that gives deformation of a body. The program first divides a body into parts, then it formulates the forces working among them, and solves the deformation of the entire body.

First, he calculated deformation of a honeycomb mirror and a thin meniscus mirror. A honeycomb mirror, according to its design philosophy, has high rigidity due to its structure. But he noticed that a honeycomb mirror has an inevitable collapsing deformation when its position becomes close to vertical. Before I learned his results, I was attracted by the idea of Dr. Angel of the University of Arizona to cast a light structured mirror that is strong against deformation due to its own weight and not to put much effort on sophisticated support system. Dr. Watanabe's calculation taught me that Dr. Angel's mirror had some other problems.

Deformation of a thin meniscus mirror can be avoided if it is supported by a sufficient number of support points. However, it had two problems. The first problem was that the upper part of a mirror hangs when the mirror position is close to vertical. If we could support the mirror with forces tangential to the mirror surface, this problem would be solved. But a support point put on the back surface of the mirror pushes the mirror only in the axial direction. In order to have tangential forces, we have two solutions; either that the support points are fixed to the backside of the mirror, or the support points exert forces at the local center of gravity that is at the middle of the mirror thickness and is accessible by a hole dug from the backside. The second problem was the accuracy of forces exerted on these support points. When there are support points of between two hundred and three hundred, one support point supports weight of approximately one person. The accuracy of force required turned out to be five grams. If this accuracy is not obtained, we may have an averaged mirror surface close to the designed one, but we have local surface errors. These errors result in the disturbance on the light wave and an image at the focal plane is blurred, and the brightness and sharpness of an image is degraded.

Dr. Hiroyasu Ando and Dr. Masanori Iye were very good at these kind of calculations. Dr. Iye was a young researcher of galaxies in TAO whose thesis I supervised. He was outstanding in his clearness of logic and in mathematics. He was also a good experimental physicist. The problem of how a circular disc is deformed when extra force is put on it is similar in a sense to an astronomical problem of what kind of spiral waves are formed in the galactic disc structure. And it has common characteristics to the oscillation of stars like the Sun. Waves and oscillations that are formed and are growing in celestial bodies are closely related to its structure. Therefore, analyses of waves and oscillation lead to understanding of the internal structure of stars or the structure of galactic discs. Staff of the Project Room applied their knowledge of astronomical research to the studies required by the telescope project. I thought such preparation work was all right for staff of my age or older including me. But I felt sorry for young staff. They were supposed to be fully working on their astronomical researches. As the representative of Research of Special Promotion with the subject of galactic structure, I worried. I thought,

'I need this telescope in order to study galaxies at the top front of astronomy.'

As I was caught up with the telescope project, co-workers Dr. Okamura and other staff of Kiso Observatory had to bear the burden of doing research without much help from the representative of the special research fund.

After the survey of Corning Glass Works, I dropped in Contraves, Inc. Contraves was one of the several companies that responded with

"We are ready to challenge the polishing of the large mirror."

It was natural that no company that responded positively had not experience of having polished a mirror over the size of four meter diameter. Contraves was located in Pittsburgh, Pennsylvania. As it was close to Corning, I decided to drop in. Another reason that made me visit this company was that I heard this company succeeded the technology of a polishing company called 'Brashear.' The oldest small telescope of Tokyo Astronomical Observatory was manufactured by Brashear & Co. That company had already been dissolved and its technology was inherited by Owens Illinois, which was dissolved again to transfer the technology to Contraves. I did not expect to find here an example of mergers and dissolution of American companies that leave its technology to be inherited to new companies with the engineers and technicians.

It was hot in Pittsburgh. Before I arrived at the city, I thought that I would be visiting 'the Iron City Pittsburgh' as I learned in the class of geography of middle school. But what I saw was completely different from what I imagined. As I came close to 'Three Rivers' where two rivers merge into one, a dynamic town surrounded by beautiful green hills appeared. In old times, there must have been hundreds of chimneys. But there I found none of them. I saw silhouette made by many beautiful buildings with individuality. The river leisurely filled water with many boats going to and fro. Beyond the river, I saw a large baseball ground that is the home ground of Pittsburgh Pirates.

Contraves, Inc. was located in a hill region twenty minutes of drive from the city along one of the rivers. It was smaller than what I thought. The salesperson who came out to greet me had a baseball hat on. He said,

"We have polished two meter class mirrors. Soon, we will polish a four-meter class mirror."

He added that the mirror would be a thin monolithic one. He also said,

"I cannot disclose it officially, but it is a mirror for an institute of American Air Force."

An engineer showed me around in the factory. What I saw were only small optical parts except one two-meter mirror that was being measured for test. This mirror was thick. The engineer said,

"We have high level technology of polishing and making glass,"

and showed me proudly a light weight mirror whose backside was bored to honeycomb shape, a polishing machine of aspheric surface, and a small but genuine thin meniscus mirror. It was true that high level technology was needed to manufacture these parts, but I could not judge how much is the difference compared to Japanese optical companies where I ordered the balloon borne telescope and the optical systems for rocket launching. I asked hesitatingly,

“Where will you polish the 300-inch mirror?”

He immediately answered,

“Our company rents an old mine of limestone at the upper stream of this river. The mine has a large vertical tunnel. We polished a two meter mirror there. We plan to polish the four meter mirror there, too.”

I went there to see the polishing factory. It was a large old mine of limestone. Many companies rent its space and used. One company used the space as storage, another company cultivated mushrooms. After passing these companies and on entering one of the branching tunnels, I saw the entrance to the polishing factory. It was not used at that time, and it was humid inside the polishing factory. The engineer who was guiding me around said proudly,

“When we use it, we will put air-conditioning to control the humidity and temperature. It is quiet here.”

The most difficult process in the polishing is the measurement of the mirror surface. When a large polishing machine is installed, polishing is achieved after certain time of wrapping. A circular disc called ‘wrap’ is put on the mirror blank and is rotated while liquid mixed with polishing powder flows. The glass blank under the wrap is also rotated around its center. It is necessary to adjust the size of the wrap, the pressure force to be exerted on it, and the rotational velocities of the wrap and the mirror blank. But they are not of much importance. The only thing to be done is to polish the surface slowly so that the measured mirror surface come close to the designed value. It is important that the measurement is accurate. For a large mirror, because its focal length is large, the path length of the laser light that is emitted by the source, reflected by the mirror, and comes back to the interferometer is over fifty meters. A small vibration of the measuring instrument or the mirror, or small fluctuation of air, or temperature gradient of air between the mirror and the instrument would easily degrade the measurements. So, an environment like this isolated from the outer world was ideal.

“If we make this vertical tunnel higher until we reach the top of the hill, we can polish a 300-inch mirror with a focal ratio of 2.0. We will dig down a little bit to secure necessary length for that.”

“How do you carry in and carry out the mirror? How do you transport the mirror?”

“We have to make a new entrance for that. It can be done. It is necessary to carefully design it so that roof-fall does not take place.”

I looked up the ceiling of the tunnel. I noticed water drops are running on the surface of rocks. He continued as if everything had already been calculated,

“The polished mirror will be transported by the river boat. From the Ohio River, we go down the Mississippi River until New Orleans. Then we pass the Panama Canal, then come to Hawaii.”

In the tunnel, it was cool but humidity was high. It did not fit for a long discussion. When we came back to the headquarter of the company, we checked a large map of America. I recognized a water route running North-South direction from Pennsylvania through New Orleans. On the Hawaii Island, we do not have ‘a water route’ to the summit. The engineer joked,

“How about to ask UFO to carry the mirror to the summit?”

and winked. He looked very bright. He was not fat, and was not as tall as an ordinary American. A little bit nervously, he touched his glasses with his fingers to change the position.

Dr. Ando took charge of study of polishing the mirror surface. The specification of accuracy of mirror is not simple. Representation of roughness of surface should include not only the difference of height but also length and width of the valleys and mountains. The specification should be

‘accuracy of the surface for characteristic length of so and so should be such and such.’

Unevenness for large characteristic length is not distinguished from the deformation by the error in supporting strength. The smallest characteristic length will be the size of glass particles. Such small roughness causes scatter of light wave and the resulting image is blurred with halo, thus the surface should be as smooth as possible at this smallest characteristic length. Scattered light of bright stellar image makes detection of faint celestial image from the edge of the universe impossible. It is better that unevenness at all characteristic length is small. But many elements such as measuring instrument, accuracy of the polishing machine, and accuracy of the rotating support table come into the measurement of surface accuracy. When a certain level is attained, further work will be time consuming. The final decision when to stop will be a difficult one. Polishing is similar to excavating a well. We cannot work ahead. We have to work at the proper time. If it goes wrong, we have to start from the beginning.

Mr. Masao Nakagiri and I took charge of study of aluminizing the glass surface of the big mirror. Mr. Nakagiri is a technician from Okayama Astrophysical Observatory. He worked with me since I moved to TAO, so I knew him well. He was dauntless, and did what was told to do. We surveyed companies in and out of Japan, but no company had ever aluminized such a big mirror. We also asked for accuracy of thickness and homogeneity of aluminized film for the large reflecting telescope not comparable to any other. Some companies could aluminize a large mirror like a gilt folding screen, other companies had high accuracy technique up to the size of lenses of cameras or glasses. The vacuum aluminizing tank like the one we have at Okayama Astrophysical Observatory is specifically ordered for mirrors of astronomical telescopes. It seemed to me that to have good homogeneity with a tank for an eight-meter class mirror is difficult. We also studied spattering method in which ion-beam hits aluminum instead of vaporizing aluminum. But we were not convinced by this method either. Finally, we ended up with a gigantic vacuum vaporizing chamber. Cleaning the mirror before aluminizing could not be done manually. We needed to design a large automatic cleaning machine. After many experiments, we found that it is difficult ‘to dry the cleaned mirror uniformly.’ Many staff joined us later toward the solution of this problem.

3.4

Based on the survey made by that time, it was clear that the summit of Mauna Kea, Hawaii was the most excellent candidate site. The height above the sea level is 14,000 feet. And the atmospheric condition depended on this height. The site was already working as an international observatory. The infrastructure was getting better thanks to the help by the State of Hawaii and the University of Hawaii. Transportation between Japan was good. No political disturbances were expected. Considering these conditions together with the astronomical requirements, Mauna Kea was the reasonable choice for our telescope site.

‘Can we construct a Japanese telescope abroad?’

This was the largest unsolved problem for which no answer was shown to me yet.

I gathered my courage and visited one of my classmates of high school who was working in the Ministry of Foreign Affairs [2].

“In the Antarctica, we have Japanese observation base. But Antarctica does not belong to any country. Hawaii is a legitimate American land. Everything will be treated differently in Antarctica and in Hawaii.”

Such was his comment as a diplomat. I asked,

“Isn’t it the same because both are out of our country? The Antarctica base was built out of our country. Wasn’t it?”

“Well, that is a rare exception. It’s run under an international treaty.”

“Isn’t there any Japanese facility in foreign lands?”

I asked again.

“I have not heard of any except diplomatic establishments abroad. Well, Japanese schools and Japanese Cultural Halls, they are local corporations having special status. They rent buildings. It is not that Japanese facility or instruments are placed in foreign land."

"Can you make survey if any Japanese governmental facility is constructed in foreign land? I don't think any staff of a governmental office except you will take my problem seriously."

I was a little bit worried of asking him who was at a high ranked position such a laborious survey. But I had no other choice. He thought for a moment, then said,

"O.K. I will let my people survey the problem. It may take time though."

Although everything was pending in Japan and I could not tell with certainty how things will turn out, we frequently visited Hawaii. Along with collecting various information at the University of Hawaii and in the local community, we went up to the summit at every visit to survey candidate sites for the telescope. On the summit of Mauna Kea, thirteen possible telescope sites were designated as the sites permitted by the end of this century. This plan was agreed upon by the local community after the environmental assessment. Four sites were occupied by telescopes of two to four meter class of the University of Hawaii, United Kingdom, Canada-France-Hawaii, and NASA. They were already in operation. Besides these big telescopes, there were two small 0.6 meter telescopes. These six telescopes were placed on a ridge. In a basin surrounded by the ridge where strong wind is avoided, two radio telescopes were being constructed, namely the fifteen-meter millimeter wave telescope of the United Kingdom, Canada, the Netherlands and the ten-meter sub-millimeter telescope of the California Institute of Technology (Cal Tech). Five sites remained untouched. One was for a radio telescope and was on the northern shield a little below the ridge. Four others were on the ridge. One of them was almost decided to be the site for the Ten-Meter Telescope (TMT) of the California Institute of Technology (Cal Tech). TMT group aimed at the east root part of the east-west ridge of the ring shaped volcanic cones and have been continuing for two years observation of meteorology and monitoring observation of stellar images. Student part-timers came in turn. They put T-shirts and jeans. Boys didn't shave, girls didn't care about their hair. They were well tanned by the strong ultraviolet light at the summit. I heard that Cal Tech had already executed the Memorandum Of Agreement between the University of Hawaii and Cal Tech and secured that site. TMT was an ambitious project of using thirty six segmented mirrors to make the effective diameter ten meter. We had to hold back that site although the agreement was only provisional before the construction fund is admitted and the main agreement is executed.

There was one more site on the East ridge between the University of Hawaii telescope and Canada France Hawaii Telescope. It was for the National Optical Astronomical Observatory (NOAO), I was told. In 1970s, NOAO constructed 150-inch telescopes on Kitt Peak, Arizona and Cerro Tololo, Chile, and was holding a big group of telescope engineers.

U.S.A. has National Observatory for Optical Astronomy (NOAO), National Observatory for Radio Astronomy (NRAO), and the Naval Observatory that is a national institute for positional astronomy determining the time and calendar. Besides national observatories, it has many state observatories and private observatories such as Smithsonian Astrophysical Institute, Mount Wilson and Palomar Observatories of the Carnegie Foundation, and has many telescopes making pyramid type structure that is necessary for basic sciences. Engineers of the NOAO at the top of this pyramid structure were holding up Next Generation Telescope (NGT) Project that is a project of four eight-meter telescopes mounted on one mounting making the effective diameter equal to sixteen meter. But NOAO had not executed MOU between the University of Hawaii, and the project was not funded yet. Japanese JNLT group started site survey with three sites as candidate sites for construction, namely this site, a site near the 0.6 meter telescope at the south end of the East Ridge, and a site west to the candidate site for TMT.

JNLT project office in TAO started a cooperative study with the Meteorological Institute in Tsukuba with Dr. Ando as head and studied how wind blows and how turbulence occurs with a miniature model of Mauna Kea in the wind tunnel of the Meteorological Institute. Local wind stream created by the mountain when homogeneous wind stream from the Pacific Ocean hits Mauna Kea was studied. A probe of a micro-anemometer measures the wind speed at various height from the earth's surface. This was a laborious work. We got the results after one year's work with the help of the Meteorological Institute.

Cross sections near the 24-inch telescope at the south end showed that wind blows up and creates strong turbulence because of the pass-like topography. The remaining two sites had both good and bad points. The candidate site on the East Ridge where there were already many domes was windward against the East wind that is the prevailing wind in the summer, therefore turbulence caused by the windward structure was small but the wind speed was large. The candidate site west to the TMT candidate site had opposite characteristics. The two sites were located several hundred meters from each other. The turbulence created at each site is blown up above the earth's surface, but after traveling this distance the air heated at the surface may be cooled down. What causes light wave disturbance is the fluctuation of refractivity of the air, that is the fluctuation in density caused by the fluctuation in temperature and the content of water vapor. If there is no temperature fluctuation, turbulent air stream does not affect the light wave much. We looked into the statistical data of wind speed and wind direction at the summit during ten years and the results of the wind tunnel measurements. Clear sky percentage was definitely better in summer than in winter. The East Ridge was shallow and was crowded with domes, that made the conditions for construction unfavorable. Moreover, strong wind may have fatal effects for a thin meniscus mirror.

After we have worried a lot as to which site to choose, we decided that the site west to TMT that allows many choices in various occasions to be our candidate site. Once the candidate site is fixed, we could proceed to the next survey. There were many items to be studied;

"How is the soil? What are the stellar images at the site? "

In September, 1986, Memorandum Of Understanding (MOU) on the construction of Japanese National Large Telescope (JNLT) was officially executed. It said, as it was written in the draft, that,

‘Provided that the fund for construction is secured in Japan, provided that the Operating and Site Development Agreement (OSDA) is executed by the both parties, the University of Hawaii will sublease the designated land to TAO for a rent of one dollar per year.’

Nobody knew if the Japanese Government would admit this, so nobody guaranteed the realization of the contents of the agreement. I told to Dr. Hall about this difficult situation in Japan. He said that MOU does not bind either party.

“MOU is MOU. We are making effort until the OSDA is executed.”

He added,

“Tell me if you need any help from us. we are ready to do whatever we can.”

He obtained many documents we needed and sent them to us.

Some time after that, my friend in the Ministry of Foreign Affairs called me and said,

“I have the results of the survey.”

So, I visited him in his office.

“There was one. A very rare case.”

My friend took out documents from an envelope on which the addressee’s name and address were written in solid ink, and explained the results to me. ‘A very rare case’ meant the commemoration tower of wartime victims built in Philippine through the good offices of the ex-Prime Minister Mr. Shinsuke Kishi. This is a property of Japanese Government built in a corner of a park.

“Ministry of welfare pays the yearly management fee to Philippine. It’s quite different from a telescope,”

my friend said and looked at me with somewhat embarrassed look.

“But we now know that a property of Japanese Government can be built in foreign land.”

“O.K. It may not be impossible. But remember that it was a rare case.”

I was very glad to learn that one case was found. With the case of the observation base in the Antarctica and with this case of commemoration tower, we may conclude that we can build a telescope in foreign land. I thanked him politely and put the office-use envelope on which the addressee’s name and address were written in solid-ink into my brief case.

---

[2] Sakutaro Tanino

3.5

After we exchanged the MOU, I visited Hawaii more frequently. The flight to Honolulu took off from Tokyo late in the evening and landed at the Honolulu airport in the morning. The flight time was seven hours and the time difference was five hours. In total, it amounted to twelve hours. If we leave Tokyo at nine P.M., we arrive at Honolulu at nine A.M., and a new day begins. As we pass the dateline, we repeat the day twice. I always took supper at the Narita airport, declined flight dinner, and started to sleep as soon as I got on board. This way, I could sleep for six hours, and the next day, I could work from the morning. Sometimes I went to the University of Hawaii, sometimes I took an inter-island flight to the Big Island. When I took the earliest flight to the Big Island, I was at the midlevel facility of Hale Pohaku at 2,800 meters above the sea level by noon. I usually used a rental car for transportation. At this time, because of the small amount of the total travel fund for the project, I usually went alone.

The next big task after the execution of the MOU, was preparing the draft of the Operation and Site Development Agreement (OSDA). Dr. Donald Hall, director, and his secretary Ms. Ginger Plasch, and Dr. Len Cowie in charge of scientific affairs, attended the meeting. Later Dr. Robert McLaren joined as an associate director in charge of Mauna Kea affairs. Dr. McLaren was a scholar from Canada. He used to be the director of the Canada France Hawaii Telescope. As he knew the troubles the users faced at the Mauna Kea observatories, he was a reliable person whenever I had to solve some problems.

As I initially knew nothing about OSDA, we started studying the already established examples of the United Kingdom and Canada France Hawaii. The mainframe was common to these two agreements. The sublease of land, allocation of telescope time to the University of Hawaii, and the participation of the University of Hawaii staff to the operation committee, were the main items. The sublease fee was one dollar per year. This is paid to the Treasurer of the Government, namely the money goes to the State of Hawaii. The State of Hawaii had already spent a substantial amount of money on the development of the Mauna Kea observatories, construction and maintenance of the road, making laws and rules for the designation of the Science Reserve, and for the sublease of land to foreign observatories. It seemed that the State assumes that it can recover the investment by inviting the hi-technology telescopes from in and out of the country. For the State of Hawaii, agricultural industries of sugar cane and fruits for export and tourism industry were the only industries it depended upon. So, Hawaii wanted to change the image of the State toward science and technology. Besides, the construction of observatories created jobs in the State of Hawaii. Also it offered more chances to the people who went out from the state to the mainland to come back.

The merit to the University of Hawaii who took the laborious responsibility of standing between the State of Hawaii and the users was the allocation of telescope time. The construction costs of a large telescope are high. Operation of such a telescope also costs much in personnel expenses and maintenance. Dividing the total cost by the number of days of its operation that is usually thought to be about thirty years, cost per night is between several tens of thousand dollars to some fraction of one million dollars. Allocation of ten or fifteen percent of telescope time equals, if counted as research fund, a substantial amount of research fund to a university. The initiation fee paid at the start is to be used for the future infrastructure of the Mauna Kea observatories. The University of Hawaii pools the money paid by the observatory members, and the User's Committee decides its expenditure. The pavement of roads to the summit, servicing of commercial electric lines at the summit, installation of optical fibers between the summit and base facilities were the items in the plan.

I brought back the draft to Japan and showed it to the Group of Infrared and Optical Astronomers and the other committees of the related astronomical researchers. Most people, however, were not as sympathetic towards me at the beginning.

"It's a Japanese telescope. They are impudent to ask for a guarantee of allocation of telescope time."

"They exceed their authority for asking participation of a representative with right of votes to the operation committee."

Such were the main objection towards me. These can be interpreted as

"It's enough that they rent the land to us."

"Of course, we will pay the rent. We have to secure our autonomy."

"Don't be underestimated by U.S.A."

At these nationalistic opinions, I worried and got depressed. I felt uneasy thinking,

'This may be what ordinary Japanese people think of foreign countries and foreign people.'

As it was supposed to be a long fight against these opposing people, I could not put my research aside although the preparation of promoting the telescope project kept me busy. I used to observe at the Kiso Observatory to study galactic structures with the fund of the Research of Special Promotion Project that I started with Dr. Okamura. But my frequent visits to Hawaii made it a little heavy a burden to go there. As I had to visit Hawaii anyway, I asked the University of Hawaii for ten percent of the telescope time of the 88-inch telescope of the University of Hawaii, and had a good answer. The staff of the Institute for Astronomy were not satisfied with the decrease of their own telescope time. However, the director, Dr. Hall, accepted my request,

“By looking forward to the common use of the large telescope that will be installed in the near future, let us cooperate in research. At the same time, this cooperation could offer Japanese astronomers a good chance to learn about Mauna Kea.”

Besides this, he also agreed to receive a young Japanese astronomer at the Institute for Astronomy in Honolulu provided that he supports the Japanese observers coming to Mauna Kea to use the 88-inch telescope. These arrangements eventually prepared a situation that later the OSDA without much modification, was executed.

Soon, I myself visited Mauna Kea to use the telescope of the University of Hawaii. My interest was in the structures of individual galaxies at first, but it later expanded to the structure of clusters of galaxies, too. Galaxies a little far away, that means, say, five hundred million light years away, are a little different from the ‘present’ galaxies close to our Milky Way Galaxy. We are looking at images created five hundred million years ago and they are spatially apart from us. There are ‘clusters of galaxies’ where galaxies are crowded together, ‘supercluster of galaxies’ where clusters of galaxies are connected each other, and they make walls in the universe. In front of the large wall, there are ‘super-voids.’ It may rather be said that ‘super-void’ is the main character of the universe, and galaxies are found at its boundaries. Where many galaxies are crowded, in the long history of the universe, they collide and merge. The relative speed of galaxies is several hundred kilometers per second. Therefore, the structure of the entire cluster changes with the time of the universe. On the other hand, the world’s astronomers’ interest was on how the super-void was created.

Let’s take a particular cluster of galaxies. Individual galaxies in it are moving at very high speeds. In a group of galaxies or a cluster of galaxies that are almost isolated from the rest in the universe, the gravitational force and the motion balance. Otherwise, there would be a disruption in the timescale of the age of the universe. The gravitational force, in other words the total mass as its source, is estimated from the motion with this balance, as the presupposition cannot be explained with our present knowledge. The mass estimated in this way is more than fifty times the total mass of visible galaxies. So, without a lot of 'dark matter,' we could not reach a reasonable conclusion. 'Super-void' and 'dark matter' thus became the heroes of the universe. Those who thought,

'Such foolish thing cannot happen,'

could not deny the observational facts that came out in sequence.

At Mauna Kea, I observed 'compact clusters of galaxies'. A compact cluster of galaxies is a group of galaxies, of about ten or so, densely populated in a compact region. Dr. Shakvazian of the Byurakan Observatory of Armenia and his group, listed up between three hundred and four hundred of such groups in the 1970s. I selected about ten clusters that were estimated to be closer and made detailed observations. I found that No.205 of the Shakvazian catalogue that I observed first, was five hundred million light years away. Twelve member galaxies existed in a small sphere of a diameter of three hundred thousand years, moving at high speeds. Most of the member galaxies were elliptical galaxies whose stellar distribution was highly concentrated towards the center. Did they repeat collisions with each other? As a consequence, was the peripheral part stripped off? One possibility to support this high velocity and make the individual galaxies live on, is existence of dark matter that extends over the cluster. I tried long exposures but nothing was found in the space between galaxies. These observations were made with an electronic camera that became available for practical use at that time. The light hits the semi-conductor and produces electrons. Counts of these electrons are sent to computers and then integrated there. This technique allows one image to be produced from many exposures. I also made spectroscopic observations in order to study velocities and chemical abundances.

Since there was no other way to reach a self-consistent view than to depend on the dark matter, I decided to make a computer simulation. While I was doing the research of compact clusters of galaxies, Professor Daiichiro Sugimoto of the

Department of Cultural Sciences of the University of Tokyo and his group, succeeded in developing a 'specialized board for the calculation of multi-body gravitational motion.' We needed the relative positions of two celestial bodies to calculate the gravitational force. For a group consisting of many bodies, every combination of two bodies had to be taken into consideration. His idea was to make the calculation of the gravitational force between two bodies, by a special electronic circuit. Then a personal computer added to this board can work as fast as a supercomputer in a problem like my compact cluster of galaxies where only the gravitational force was dominant. I asked them for help and followed the evolution of the clusters of galaxies. As I expected, the gravitational field by an extended substantial dark matter, could explain the observational data. I talked about my results at a colloquium of Institute for Astronomy of the University of Hawaii and at the International Conferences.

In the year of the execution of the MOU, we summarized the site survey and surveys on the mirror material, polishing, and mechanical structure. We also made 'A Report of Engineering Survey' and submitted it to the Committee for the Astronomical Research of the Japanese Academic Council and to the Future Planning Committee of the TAO. Based on the survey report, a meeting for critical review was held of the Project of Construction Abroad of a Large Telescope, which was agreed upon as the consensus of the entire astronomical society in Japan made in the end of 1984. Review reports were generally written with good will. There was an expression like

"It was surprising that such substantial surveys and studies were done in a short period."

Some people were still critical against the project and wrote,

"It is not yet certain that the group can build a large telescope in Hawaii."

I thought they were right. Although we were the ones who conducted the survey and made the report, we could not speak up against them.

When I was in Tokyo, I often went to the metropolitan area of Tokyo from the observatory in Mitaka. Destinations were Hongo, Toranomon, and Nagatacho. Hongo meant the Admin Headquarters of the University of Tokyo. My task was to ask for help to promote the telescope project of TAO and to report the present status of the survey and preparation. Toranomon meant Ministry of Education, Science, and Culture. By that time I knew that the Research Institute Division of the Academic and International Affairs Department was the office handling matters concerning the observatory. I visited their office many times. As they were very busy, I tried to visit them whenever they had time. They said,

"You cannot think there is any prospect."

But they listened to my explanation for more than an hour.

Nagatacho meant the Diet-members. I did not know what the relations were among them, but I did not think that astronomy affected their interest much. I tried to meet every Diet-member who may be of some help to us and explained our project. Some people doubtfully asked me,

"Why did you come to see me?"

There was no way for me other than to give up in explaining to these people. I learned that there was a group of people consisting of Diet members with a special interest in education. I also learned that the Diet had a Committee for Education, a Committee for the Science and Technology, and an Investigative Committee for the System of Committees. Each political party had their counterparts. This knowledge changed my ways of reading the newspaper, and I carefully began to read the news about these particular people. I acquired to take a note when I read an article reporting of a Diet-member whom I met recently during a meeting with the Prime Minister. I also had to visit companies to make the survey. Sometimes, I had to arrange a 'study meeting' in an appropriate place in the metropolitan area. As the fund was not yet guaranteed, the statements in such a meeting were not straightforward in terms of finding out the other party's true intention.

The tour in the heart of Tokyo was a tiring job. Especially, in the midst of the hot summer, my physical strength was consumed. When entering from the hot roads of the city to the well air-conditioned buildings, I often got dizzy and had to drop by a coffee-shop to have some rest. My suits got dirty with sweat, especially at the collar and sleeves. All of my destinations were at official places where I could not visit in casual style. So, I carried my suit in my arms when walking on the road and put it on just before I entered the office. I wore out one pair of shoes. Nevertheless, I did not think that progress had been made in the people's understanding of the essential issues.

Compared to the tour of central Tokyo, the commute to the Kiso Observatory for the research of galaxies was pleasant. I forgot the bitter feeling I had in the preceding weeks when looking at the mountains of the Southern Alps and the Central Alps from my car on the Chuo Highway or from the train of the Chuo Line. I especially had a peace of mind when I got close to Nirasaki or Kobuchizawa and saw Kai-Komagatake. In its mountain skirt at Torihara, Hakushuu-cho, there were two cottages that Uta and I built with many hardships. It was, so to speak, the home of my three daughters. Uta's late mother came from Germany and stayed there a few days.

The author's cottage in Hakushu.

Torihara Hakushuu is located on a little mountainside of Koshu Kaido. It is a village consisting of about fifty houses at seven hundred meters above sea level. From the village, there is a commanding view of the Yatsugatake in the north and of three mountains, Yakushi, Kannnon, and Jizo in the south. Our two wooden cottages had black tiled roofs and white plaster walls. The village road led to the mountains on the upper side, and to the riverbed of the Kamanashi river on the lower side. Our pleasures were to fish, swim, and watch the white clouds roll across the sky.

From spring to early summer, we cut the shoots of grass bamboo, plucked the shoots of wild wisteria, and picked the shoots of the pine-trees in our garden. Our children helped us, or otherwise our cottages would have been closed in by vines and grasses. In August, the strong rapidly growing weeds gave way to the heat and lowered their heads. Then, the first day of the autumn was there. Red dragonflies started to fly around. The air became transparent and the mountain ridges seemed to be closer. It was a good time to enjoy the hot springs in mountain villages. When the wind blew over the yellow rice fields, the red dragonflies flew in masses. The village feast was over, and only the red persimmons atop the trees were shining in the sky. Clouds became thinner. Mountains got nearer. One day, the mountaintops were white, then winter started. We had our sunken kotatsu and long hibachi ready to use, and checked the water stopcock. After the dry weeds were burnt in late autumn, there was no job to do in the garden. Sometimes, we had to shovel away the snow, but most of times, we could read books with our feet in the kotatsu, baking mochi with the hibachi, and drinking tea. When we got tired of reading, we played mahjong with our children, or went skiing or skating in nearby fields. When Spring arrived, the snowy mountains seemed to be sunbathing on the other side of the fogged windows. The ground got heated softly and started to move. The trees in the mountain burst into red buds. Meanwhile, they had light-green crowns in this ridge then to next ridge.

My three children grew up as a part of the nature of Torihara. My daughters did not care to catch earthworms and lizards. Fishing was the favorite of the eldest daughter Monique. She often caught a large dace, cleaned the guts, then salted and baked it. Uta was the ‘teacher of vegetation’. She taught the names of plants. We hunted mushrooms in the woods and sautéed them with butter. We bought illustrated books of plants, animals, and wild birds in order to find out the Japanese names. I pulled out my hand-made eight centimeter telescope that I made in my boyhood, and all of us enjoyed looking at the Milky Way or the Orion nebula. Our children helped us, and created their own play-games. When one of them was not seen in the house, she was playing in the neighbor's. They said wonderingly,

"People at Torihara do not say GAIJIN."

Uta was relaxed here.

The trip to the Kiso Observatory reminded me of such things. In the past, I went to our cottages every weekend, but these days the telescope project kept me busy and I could not be there with my family. Our children went there along with their friends and Uta along with her students. But I was tired during the weekends and usually stayed in my house in Tokyo doing nothing. Occasionally when I went to Torihara, I did not go fishing although it was my favorite pass-time. The riverbed of the Kamanashi river, where I used to go down through the reed grass fields, was covered by concrete, and the river black worms that were used for fishing were not seen any more.

3.6

The biggest task for a thin meniscus monolithic mirror was its support system. An ordinary thick mirror resists deformation by gravity by its rigidity that comes from its sufficiently big thickness. As the posture of the telescope changes, the mirror is softly supported so that deformation is not produced by force on special part. It is also necessary to have a system to keep the mirror fixed, relative to the mechanical structure. The most commonly used system is a combination of lever and weight. As the telescope tilts, the force pushing the mirror up from the backside, balances automatically. When the telescope is directed at a low altitude and the mirror is standing almost vertical, the force pushing from the backside becomes small. A hard gum-belt holds the mirror by its periphery so that it does not slip down. In the case of a larger mirror, a steel belt is used instead of gum-belt.

For a thin meniscus mirror of twenty centimeters thick, the ordinary method cannot be used. As it is not rigid enough to keep its figure by itself, it needs to be supported at many points. It is the same as trying to keep a thin-sliced konnyaku in a fixed figure. (konnyaku : jelly-like food made from the starch of sticky potato.) The konnyaku plate should not either deform or shift both when the telescope is pointing the zenith which means the mirror is horizontal, and when the telescope is directing horizontally that is when the mirror is vertical.

We asked most prospective researchers and engineers of universities and companies to study the support system and held many meetings over a long period of time. The engineers of the companies were very much interested in the problem, but they could not start a developmental study requiring a lot of work, time, and money because no funding was assured yet. We tried to avoid in having any close relationships with a specific company, so meetings were open to everybody. When it was necessary to make a detailed discussion with a particular group of people, we arranged to hold such meetings in a rental conference room outside of the observatory.

Theoretical analysis gave two solutions. In the first solution, the konnyaku plate is pasted to a frame from the backside and at the periphery, and this frame is controlled. In the second solution, we put many bars to the konnyaku plate from its backside and control these bars. In this case, of course, we hollow out narrow holes on the backside of the konnyaku plate. In the first method, it is dangerous to completely paste the plate to the frame because of the difference between the thermal expansion coefficients of the mirror and that of the frame. Pasting is done at grid points so that the difference of expansion is absorbed within the distance between grids. Actually, the ends of many sticks are pasted to the mirror, so the structure is quite similar to the one by the second method. The difference between two solutions is whether the sticks are pasted to the surface or the sticks are inserted to holes. Many computer simulations of Finite Element Method were done with the mainframe computer of TAO. Although throughout the mirror there was the same thickness of twenty centimeters, because of the curvature of the concave mirror, it was necessary to not only push but also pull the mirror. This was necessary if we were to use the first method of pasting the mirror on the backside and at the periphery, when the mirror is close to vertical. With the second method of inserting the sticks in holes, however, if the sticks hold the mirror at the local center of gravity, it seemed that the control of the mirror could be achieved with the pushing force only. From the standpoint of control, the insertion method was simpler and had more prospect.

‘Doesn’t the thin glass break if so many holes are hollowed out?’

Glass has a homogeneous and smooth inside structure as does konnyaku. Therefore, it won’t break if there is no defect. Once it has fissure or crack, the small force causes its expansion resulting in a large breakage.

‘It may be difficult to hollow many holes without leaving any defects. Will reversing the mirror be safely done? It is unavoidable in the production and polishing processes.’

The mirror is put at a convex posture when holes are hollowed on the backside. It must be reversed upside down to the convex posture before it is transferred onto the polishing machine. Once a year, we have to remove the 7.5 meter thin mirror from the telescope and carry it into the aluminizing chamber in order to renew the reflecting aluminum film at the surface of the convex mirror. It is spine-tingling work. What determines the strength of glass? How does a crack grow? There were an unaccountable number of items to be studied. The glass specialists unanimously said on the safety of the glass,

“It is dangerous, of course. But, if small cracks are removed with hydrogen fluoride, it’s O.K. Find the small cracks during the early phases. The growth of cracks accelerates.”

Their assurance never lightened our anxiety. Rather, it grew day by day.

Another problem was the sticks to be inserted to holes on the backside of the mirror to control the figure. This robot arm was called the ‘actuator.’ A thick actuator is solid and easy to work with. But a thick actuator requires a large hole and is heavy.

An actuator has to transfer force in the direction designed smoothly when the posture of the mirror changes. In order to achieve this, a complicated precise mechanism was required. It was estimated that the diameter of an actuator is more than ten centimeters. More than three hundred of them were required, otherwise the mirror surface between the actuators sags down by one tenth of a wavelength. An actuator holds weight of about one man. The biggest problem was its accuracy. If the force put by the actuators are not accurate, the actuator system will hold the mirror in a wrong way. If the actuators are accurate enough, any large-scale deformation of the mirror after polishing can be corrected by adjusting the distribution of force, if the scale is larger than the distance between the actuators. From the 'control' point of view, the actuator system was attractive because of its simple relationship between force and deformation. In order to realize this, the accuracy of less than five grams for the total weight of fifty kilogram is required. One per ten thousand of accuracy! The sensitivity of the finger of the robot arm should have a sensitivity of ten thousand or more. One task of making this mechanism was in producing the force, but another task that is more important than the first task was the detector sensing force. When we pursue the ideal control of a 'thin meniscus mirror,' developing an actuator with the sensitivity of ten thousand was the hurdle to be passed over urgently.

The Scientific Research Fund of MESC has a category called 'Experimental Research.' This fund is for developing new technology when governmental researchers cooperate with private companies. The TAO group applied for the 'Experimental Research for Control System of Active Support of Thin Meniscus Mirror.' As the amount applied for was big, the surveying officer inquired us,

"Do you think you can really make it? Please explain your plan from the basics. It doesn't matter if it takes much time."

The explanation took half a day. Representatives of the JNLT project office explained the Large Telescope Project to the surveying officer. We talked about how it is difficult to fabricate a large mirror, what are the merits of the thin meniscus mirror, and what tasks were to be developed. The surveying officer patiently listened to our talk and asked many questions. We wanted to believe that the many questions he asked proved that he was very interested and was trying to understand the project seriously. He said,

"O.K. Do your best."

He did not forget to add,

"But, don't forget that approval of this experimental research does not mean approval of construction of telescope. You see? This is only an experimental research of support mechanism with high sensitivity."

He also said with a serious look,

"I have heard of the Large Telescope Project in Hawaii. That is a kind of project whose realization is desirable."

We were not sure if he meant that,

'All staff of MESC wish it to be realized,' or

'It does not seem that the project will start soon.'

This experimental research was funded for the fiscal years of 1986 and 1987, then in the third year, the fund was given as Cooperative Research with Private Companies. In the Cooperative Research with Private Companies, many companies cooperated but the main party was the Engineering Study Group of Mitsubishi Electric Corporation that specialized in servo-control system. The structural design, fabrication of engineering model, and performance tests were done. The last hurdle was, as we anticipated, the development of the force sensor with the sensitivity of ten thousand. The last hurdle was cleared, after many modifications, by electronically detecting the resonance frequency of quartz that changes with the pressure it receives.

In the fiscal year 1987-1988, we had another research fund of MESC, made nine actuators, and experimented to support a one-meter thin mirror controlled by an engineering model. This experiment was done in a large tent outside of the buildings of the Tenwa region in Banshu-ako. Later, experiments were continued in the laboratory for a balloon-borne telescope on the Mitaka campus of TAO with Dr. Iye as the head of the experiment group. For this experiment, the engineers of TAO developed a special instrument for measuring the mirror surface called 'Shack-Hartmann instrument.' This experience helped us a lot when we later developed 'adaptive optics' that corrects disturbances of light waves by the earth's atmosphere. Eventually, the results of the experiments that continued for five years, determined the system of Japanese large telescope. We were sure to actively support a monolithic 'thin meniscus mirror.' Application of patents related to this experiment was submitted and later approved.

Seven countries of the European Continent operate the European Southern Observatory (ESO). Germany, France, and Italy are its main member countries. At this time, ESO was promoting a Very Large Telescope (VLT) Project consisting of four 300-inch telescopes in Chile. ESO was studying as the main mirrors of 300-inch telescopes honeycomb mirror developed in U.S.A., segmented mirror, thin meniscus mirror, and metal mirror. Among these, servo-control experiment for the thin meniscus mirror was already started. They were ahead of Japan in an experiment of a control system with a miniature model, but Japan was leading in the experiment of real size model. Naturally, engineers of companies were burning to win the competition. A group of the Communication Factory of MELCO consisting of engineers, Mr. Noboru Ito, Mr. Izumi Mikami, and manager Mr. Chikao Kinoshita, worked hard so that they could present better results than the European group. The United Kingdom once sounded us about a possibility of constructing a telescope together, but it was thought to be too premature to put the idea into practice, and this fizzled out soon.

Although neither group of Japan, U.S.A., and Europe was allocated for the budget of constructing a telescope, the developing study of basic technique and survey, was done enthusiastically. As the final target was the challenge to the edge of the universe, that was common to all the humankind. The race among the three groups was keen but very fair, with cooperative spirit running at the bottom. U.S.A. and Europe held international conferences on the large telescope techniques with an interval of two years and Japan was invited to these. It was in 1988 that Japan could host this conference. In every country, companies contribute something to the developmental study related to telescopes. In general, companies do not make information open. But in these international conferences on large telescopes, the most necessary information were exchanged by participating groups, through various levels of contacts that are either official or private. It was too regrettable to hide the knowledge found by us to the others. All the participants of astronomers and engineers dreamed to direct a large telescope to the edge of the universe as soon as possible. American and European friends often said to us,

"Come and see if you wish to know."

This was very helpful to us because only Japan did not have experience of constructing a three-to-four meter class telescope.

3.7

1987 was the year that the JNLT project office of TAO was most active in the survey of the project. Along with the study of the mirror support system, there was a design study of the 'building' that would house the telescope and work as a part of it. With a 300-inch class telescope, nothing can be done manually, although small telescopes are handled manually. Everything is handled by machine. So, the building itself becomes a huge 'robot' that rotates with a telescope in it. Construction cost of this building accounts for a substantial percentage of the total cost.

The height above the earth's surface was the first problem. If a telescope is installed on the ground, it will suffer the effects of 'ground-level turbulence' even if its location is in the best place on the summit of Mauna Kea. The fixed point is the crossing point of the horizontal axis and the vertical axis of the telescope, The higher the height of the fixed point is, the less a telescope gets effects from the surface turbulence. But the construction cost is high. The cylinder post, made of reinforced concrete, on which the telescope is installed, should not vibrate. The base of the outer building and the base of this cylinder post are separated from each other. If the cylinder post is high, it suffers from vibration, and the resonance frequency becomes low. The interval of wind breath is between one and several seconds. The average wind velocity on the summit of Mauna Kea is seven meters per second. The best form of the building depends on winds.

"Should we adopt an ordinary dome type roof or a box type roof as is adopted by MMT? Should we rotate the entire building or only the upper half? "

There were many items to be studied.

Two jobs were to be done; the measurement of the dependence on height of the surface turbulence at the candidate site of construction, and the study of the airflow near the building with a miniature model of the building in a wind tunnel. The wind tunnel experiment was performed in cooperation with the Research Institute of Aero-Space-Engineering located close to TAO. We used water tanks and water flow instead of a wind tunnel. When we look at large structures like a model of the mountain, we are interested in large-scale flow. When we are looking at buildings, the details of the flow should be studied. So we recorded the image of a water-flow colored with dye. Unexpectedly, we found in case of a low spherical dome roof that the surface turbulence stirs up along the spherical roof of the building and comes up to the opening of the dome from which the telescope peers into the sky. It is desirable to put the telescope mounting at least at the height equal to the radius of the building. In the preliminary design of the 300-inch telescope, the length of the telescope tube was fifteen meters. The radius of the building should be larger than this. Then, the mounting should be installed at a height of fifteen or twenty meters.

We decided to build a thirty-meter steel tower at the candidate site of the construction area, to measure the thickness of the surface turbulence layer with detectors at various heights. Professor Hiroyoshi Tanabe, who was a specialist of night glow, became the head of the 'site test' group, and Dr. Nariai was the manager.

Three assistants, Takeshi Noguchi, Masao Nakagiri, and Akihiko Miyashita who had worked for Professor Tanabe for a long time, went to Hawaii, for two months each. Mr. Miyashita had the experience of performing night-glow measurements on an isolated island for a long period. He had a tough and rational spirit. This survey was done with the Scientific Survey Fund Abroad that is one of the Scientific Research Fund of MESC.

"This is only to study how the surface turbulence behaves at the best site in the world. The fact that this fund is allocated to you is not at all related to the construction of telescope."

The officer of MESC in charge called our attention to that. It was decided to make the detectors ourselves with the help of the University of Hawaii, and the order for the thirty-meter tower was sent to the mainland of U.S.A. It was natural that the officer of MESC had to cautiously mention this, but we dreamed that the construction would start any time.

The tower, however, did not come soon. After we sent out our staff, we had to change the specification and modify the procedure of transportation. Preparation did not go as smoothly as we had anticipated at first. This was the first experience of difficulty of constructing abroad. On the other hand, we felt that the staff of the University of Hawaii and the Mauna Kea observatories, not only astronomers but also engineers and technicians, were friendly to the Japanese project and were ready to help anytime. Otherwise, the three technical staff who stayed alone at a time could not have endured their task of two months. I later heard that some of them played tennis and some others read several tens of pocket books in order to behave themselves without getting short-tempered, that might have happened because of slow progress of the arrangement.

During the waiting days, the measuring instruments were tested many times. The engineer of the University of Hawaii helped our staff to mend the instruments whenever something went wrong. After many struggles, we had the tower, the measurements started and data were obtained. A few months after measurements, the engineer had to leave the University.

The picture sent from the survey team showed the white tower standing against the blue sky supported by four wires. That was the candidate construction site of our telescope. The measurements lasted for two months. Analysis could be done with the data of that period. After the measurements were over, the analysis of data started. Professor Yamashita wrote the report of how surface turbulence decays with height. Professor Yamashita said,

"We need twenty seven meters."

The number was a little larger than we expected.

"Is it the height of the fixed point?"

The fixed point is the crossing point of the horizontal and vertical axes.

"O.K. A telescope never looks down. When the telescope is looking up, the roof of the building will be fifteen meter above the fixed point. When the telescope is tilted, the height is between the two values."

"When the telescope is tilted, it is looking through the surface turbulent layer longer. Therefore, the fixed point

Sensors for measuring the atmospheric turbulence are set at several heights from the ground-level. Now, our engineers are setting the top-part sensor. ©NAOJ

Thirty-meter tower to measure the hight of the surface turbulence layer. ©NAOJ should be higher."

"When the turbulence is strong, seeing is bad no matter at what height the fixed point is. So, data of such nights can be put away in making the average."

After many discussions like this, we ended up with the height of the fixed point of twenty-three meters. Then the cylinder post on which the telescope is installed would be fourteen meters high. Little by little, our image of the building became concrete. The main mirror weighs twenty tons, the support structure weighs also twenty tons. Then the mechanical structure of the telescope would weigh between two hundred and three hundred tons. The upper part of the building that rotates with this telescope structure might weigh six hundred tons. It may sound strange to estimate the cost by weight, but I once heard the average cost is one million dollars per ton. Using this scale, the cost of our telescope was estimated to be three hundred million dollars. Strikingly enough, this number matched with the figures obtained from the statistical data. In comparing the cost of a large telescope and diameters, we have an experimental law although there is some scatter. Cost is proportional to the diameter to the power of 2.7. As we are concerned with solid body, 'proportional to the cube of the diameter' may sound natural. But every time the largest telescope is made, many devices might have been made to reduce the cost. The statistical data used the U.S. dollar value at present. If we use the rate of two hundred and thirty yen per dollar, our telescope costs one hundred and thirty million dollars. This does not sound strange. If we add the building and instrument cost, the total cost will be more than that.

American and European astronomers had already an infrastructure and were operating three-to-four meter class telescopes. Japanese astronomers neither had an infrastructure nor organization for a large telescope. Sometimes, we got anxious thinking,

"Can we really make it?"

although usually our time was occupied by the engineering survey. But no one said it explicitly. Some nights, I could not sleep, when thinking of the future. But there was no way to go back. We had to make clear what was not understood and to find out the next task. I thought of the other main members of the JNLT project office carrying out their jobs with feelings similar to mine. People around us supported us, but they seemed to be standing at a certain distance from us.

When we got the approximate size of the building, we decided to study its design. The astronomers will use the telescope. But it is most probable that visitors will only look at the building from outside. A dome with spherical roof is thought to be a symbol of an observatory. We wanted to create a futuristic design. So, the study of the design started before we studied the functions and inner structures.

The architectural designer listened to our talk and came back three weeks later. He brought in five sketches. He said,

"We have several drawings. Which do you prefer?"

We thought we had explained in detail that the building must resist strong winds, and the doors are opened when observing, etc. But none of the sketches was at the level we wanted. It might have been that we forgot to explain to them something very important. We forgot to explain to them about the basic knowledge of the functions of the building. Instead we were busy telling them about the impression the visitors may have on the building, such as the astronomers' ambition is transmitted to the visitor, or the intention to be heading into the future in this space age.

We explained to them again. The second sketches were better, but were lacking something. It was because we have not studied what exactly should be inside the building. So, we had to stop studying the design of the building. We started to study the plan of the usage of the inner space, location of instruments, and the strengths of the ground where the bases for the cylinder posts and building were to be built. Thermal design was as important as the structural design. We decided that our basic policy is to shut out the solar heat flowing into the building and to cool the telescope and its surroundings forecasting the environmental night temperature in order to avoid turbulence in the building. We started experiments and calculations to realize our goal. We decided that the building should be almost cylindrical. It seemed that the shiny stainless steel or aluminum was better than the commonly used white paint of titanium oxide for its outer wall. The white painted outer wall prevented the occurrence of heating by the solar radiation, but it emitted radiation at night time and cooled off too much, resulting in the creation of turbulence. We also wanted to control the airflow inside the building.

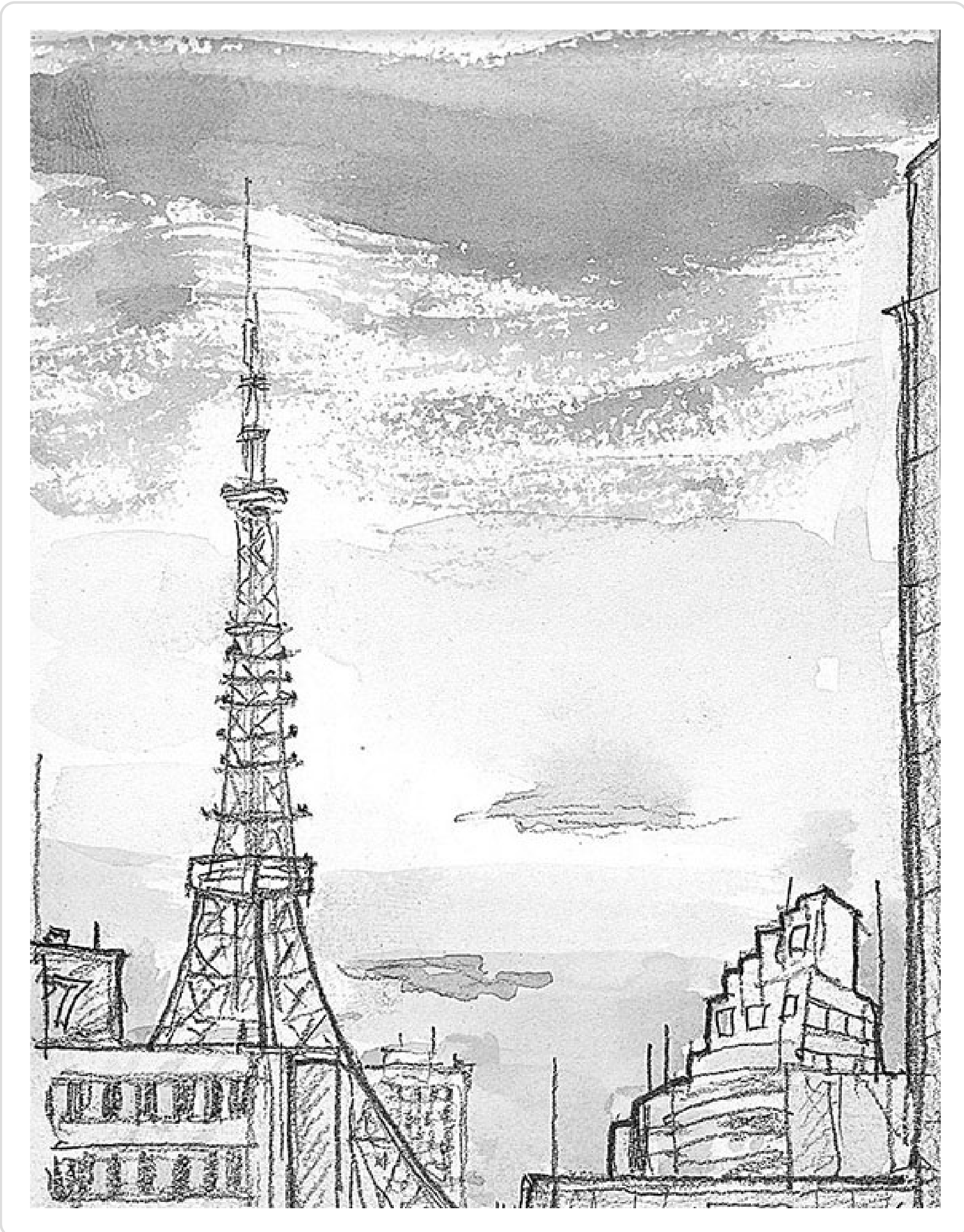
I visited libraries and laboratories of engineering, and read textbooks of 'Thermal Engineering.' I knew the 'principles' of convection, radiation, and conduction through physics. When we faced the issue of temperature distribution in the building and its control, we lacked something other than the principles. There came in 'material'. In many cases, its complex characteristics were known only by experience. Most members of the JNLT project office got the degree in science. They were apt to reason everything. Therefore, it took time to decide what should be done next. In the meeting, when we were discussing about engineering with researchers from other than the observatory, or engineers of companies, they reached a conclusion very quickly. I thought that the engineers were great. In American and European observatories, there were as many engineers as astronomers, and quite a number of them had degrees in engineering. I thought,

'If the observatory is separated from the University of Tokyo and becomes a national observatory, I wish to make groups and organizations responsible for astronomical engineering.'

[Published] **Keiichi Kodaira/Kyoji Nariai**: **2016**, NAOJ-Books : Makali'i in Hawai'i.

Chapter 4

No Law to Forbid It



4.1

It was the summer of 1988. I was in Baltimore. It was hot and humid. I was not in good health at that time. Walking up and down the slopes of the port city was very hard to me. From time to time, I felt a little bit of pain of stomach. Probably it was caused by the gastric ulcer which I suffered from when young. Otherwise, I was in good health. But I was already in my fiftieth, and the hot and humid weather was hard to me. The General Assembly of the International Astronomical Union (IAU) was being held at the Convention Center of this historic city of Baltimore. Coming out of the air-conditioned conference room to the hot outside space, I felt quite tired and was not sure if I could walk back to the hotel.

Long time ago, immigrants from Europe and slaves from Africa landed at the inner port facing the Chesapeake Bay. The Convention Hall next to the port was filled with more than three thousand five hundred astronomers from all over the world. As I was elected to chair the session of the thirty-sixth committee (Theory of Stellar Atmospheres) at the General Assembly held in Delhi of India three years ago, I had lots of works to do; report of progress during these three years, chair of the session of scientific discussions, and the business session to elect the president of the committee for the next three years. As all of these strained my nerves, I felt quite weak. Moreover, it was anticipated that Professor Kozai of Japan would be elected as the President of IAU.

'Special Nominating Committee' assigns the candidates of the President and other officers. I was among the five members of the committee who were elected at the General Assembly held in Delhi three years ago. The committee, under the command of the President Sahade, was working for the selection of the candidates of the next president and the vice president, and the candidates of the president and the vice president after the next. Just before the General Assembly at Patras held six years ago, the president Bappu suddenly passed away. Because of this, the rules of the Union were changed at the General Assembly of Delhi. It was decided that the candidates of the president and the vice president after the next should also be selected. The wishes of the representatives of the countries and the research fields were not the same. So, the members of the nominating committee did not reach an unanimous solution easily. I insisted that one of the vice-presidents should be a Japanese, which was the wish of the Japanese researchers for a long time. But there was also a strong wish of 'a vice-president from China.' This had been a pending issue since China joined the IAU, I was told. The research field of the Chinese candidate was quite close to that of ours. It was impossible to have vice-presidents from China and Japan for the same term together. After disputes, the post for the vice-president went to China.

As to the president, Dr. Sahade of Argentine was at the post after six years of Dr. Bappu of Asia. There was no possibility from an Asian country for that post. In the ordinary course of things, it would be either from Europe, America, or USSR. In the end, we had a recommendation of the candidate from USSR. The president's post is a sort of an honorary one while vice-presidents have to do business. So, the candidate was quite an aged person. After this, we discussed the selection of the candidate for the president after the next. It was only here that the possibility of a Japanese candidate was discussed. After it was agreed with a Japanese candidate, there was a diversity of opinions in the Special Nominating Committee, namely the five members of the committee and the President Sahade, as to who should be the candidate. Each member knew the researchers in his field well, but not so much of the researchers of other field. We asked for opinions of ex-presidents through President Sahade, but we did not reach a conclusion. Finally, I asked that the committee accept my opinion because I was the Japanese member of the nominating committee. So, we were almost deciding that Professor Kozai be the candidate for the president after the next. Then, the aged USSR astronomer who was informally selected as the candidate for the next president passed away abruptly. The second candidate from USSR was rather young. Some member had the opinion that he should be selected several terms later. By this time, most of the working period of three years elapsed. So, all the members agreed to have Professor Kozai, the candidate for the president after the next, as the candidate for the next president.

In the General Assembly at Baltimore, Professor Kozai, who became the first director of the newly born National Astronomical Observatory of Japan, was elected as the President of the IAU.

One month before the General Assembly, in July 1988, Tokyo Astronomical Observatory of the University of Tokyo, Mizusawa Latitude Observatory, and the Solar Radio Research Group of the Atmospherics Laboratory of the Nagoya University got together to create ‘The National Astronomical Observatory of Japan.’ Mizusawa Latitude Observatory started as an institute under direct control of the Ministry of Education so that our country join the International Latitude Observation in the Meiji Era. It had a history comparable to that of the Tokyo Astronomical Observatory. While the Tokyo Astronomical Observatory started with making calendar as its main job, then extended its work area into the basic scientific research as it became a part of the University of Tokyo as an affiliate institute, Mizusawa Latitude Observatory devoted itself to the latitude observation project. So, it was apt to be regarded as an institute whose role was over in the discussion of the Special Administrative Survey Committee of the Japanese Government. Researchers of the Latitude Observatory were doing research activity beyond the observation project, but the framework of the organization did not fit it well. The policy of the Ministry of Education was as follows; affiliate institutes of universities are reformed to become inter-university research institutes which the researchers of all the universities can take part in. These centers construct and operate high-tech large instruments, and the researchers from all the country join the management of these centers. It was thought to be a pure loss to abolish Mizusawa Latitude Observatory. We wanted to make it get together with the Tokyo Astronomical Observatory and make a new center of

As the national Astronomical Observatory of Japan was created, the sign at the gate is renewed. ©NAOJ astronomy. We wanted to create a National Astronomical Observatory which is an inter-university research institute. And it started its new life on the First of July.

Rearrangement of organizations is always difficult because each corresponding counterpart has its own situation not to agree with it. In the case of the Tokyo Astronomical Observatory, I met unforeseen resistence against leaving the University of Tokyo to which the Observatory was affiliated.

“There is no merit to leave the University of Tokyo. I hate to do duty of servicing users in an inter-university research institute. Research is most important for us researchers. But in such an institute, we have to abandon research. I heard that the President of our university said what if a large telescope is constructed as an instrument of an affiliated institute. The Ministry of Education has not promised us to give us a large telescope upon our transferring to an inter-university research institute. I cannot agree with an uncertain story like this.”

There were hundreds of such opinions. Once such opinions were stated, those who were anxious about the change and those who were reluctant to lose the fame of the University of Tokyo made the steps to the rearrangement slower. Discussions within Mizusawa Latitude Observatory must have been harder ones. However, as our observatory was a part of the university, decisions were based on the consent of individual staff. So, one faculty meeting was followed by another on the next day. Before the decision of requesting fund for transferring to an inter-university research institute, discussions in the faculty meeting sometimes did not end before the midnight during the preceding year and the year before the preceding. A certain faculty member even said,

“You are a swindler to collapse the Tokyo Astronomical Observatory with a trick of the large telescope project.”

But the Director Kozai stood firm with an amazing perseverance.

We could not have said that such various anxieties were stupid and were based on groundless rumors. We were not assured to get a fund for the large telescope after reorganization. We were also sure that there are certain demerits in becoming an inter-university research institute. Creation of such a large organization means that it will handle quite a large amount of fund. Then, centralization of researchers in the astronomical field will certainly occur. That may disturb healthy development of the astronomical progress in Japan.

Such discussions took a concrete form in an argument to leave a part of the Tokyo Astronomical Observatory in the University of Tokyo. The scenario of the Ministry of Education is the unification of the Tokyo Astronomical Observatory and Mizusawa Latitude Observatory into one inter-university research institute. However, what happens to the University of Tokyo that has conducted research and education with an observatory? It has a post-graduate course, but can it continue research and education without any observational facility? Is it OK to 'use the facility of an inter-university research institute?' Also, there are too few universities in Japan where students can learn astronomy. In Europe or in America, it is not so. The University of Tokyo, Kyoto University, and Tohoku University have astronomy courses, and Nagoya University has an astronomy group in the physics department. Among these four, only Tokyo and Kyoto have telescopes. If the University of Tokyo loses all the observational facility, education of astronomy in Japan will meet a great difficulty.

"Let us devise a plan to leave a part of the observatory in the University of Tokyo so that education of students can be continued for the moment. In the future, let us make it into a university observatory."

The authorities concerned were against such an idea of researchers.

"Two organizations transform into two organizations? It cannot be permitted. It's like becoming richer after fire."

But it was clear to everybody that education of astronomy in the University of Tokyo could not be continued if it loses the entire Tokyo Astronomical Observatory. Finally, it was agreed to leave a research and education center for observations and experiments with three chairs. It was not easy to decide remaining persons and facility. Tokyo Astronomical Observatory had five facilities. If a selection is made of which facility or telescope is to remain, the selection of persons is automatically done. Those who remain should be active in research and good at supervising post-graduate students.

'Committee for Preparation and Study of Reorganization' which evolved from 'Future Planning Committee' studied this problem. Chair of the Future Planning Committee Yutaka Uchida, chair of the Preparation Committee Tadashi Hirayama, and I the general manager of the telescope project worked every evening in a restaurant near the observatory. The work was delicate because it handled personal affairs, but Professor Uchida patiently talked with candidates.

The biggest hurdle was what facility was to remain. It is difficult to maintain and operate a large facility. A small facility doesn't work well for research and education. The Schmidt telescope of the Kiso Station was the final candidate. Its size was at the top level in the world. Schmidt telescope with the main mirror diameter of 1.5 meter is large but is used for one purpose, to photograph a wide area of the night sky. It had accumulated a number of big photographic plates taken with the telescope. A new measuring engine to measure these plates was introduced with our Special Promotion Research Fund.

In the afternoon of the New Year's Eve of 1986, when I was preparing the Osechi (New Year's food) into Jubako (precious canteen box), chair of the Future Planning Committee Professor Uchida called me on the phone. "I am going to see Professor Keiichi Ishida, the director of the Kiso Station, and ask him to remain. Can you come with me as the chief of the Galaxy Division? I will meet you at seven at his residence."

We started to talk at seven o'clock in the evening of the New Year's Eve. We discussed every item that we had to think prior to the change; maintenance cost, persons, facilities, instruments to go to an inter-university research institute, etc. When we finished the study, it was almost the New Year. We asked him,

"At this time, we cannot see more. There is no other way than to do our best with a plan fixed. What we have to decide before the New Year is whether we leave the Kiso Station to the University of Tokyo or not. Can you accept the plan to remain?”

Professor Ishida who was the director of the Kiso Station paused thinking a little and answered,

“Yes, I accept the plan.”

We left his residence with a load off of our mind. When I came back to my house, it was already the New Year.

In the New Year, a formal committee for the study of reorganization was set forth in the Ministry of Education, and preparation of reorganization started. The last debate was the name of the new organization. Some people said that there is no problem with ‘Tokyo Astronomical Observatory.’ In fact, most observatories in the world put the name of the location at the top of its name. According to them, Tokyo Astronoical Observatory of the University of Tokyo changes into Tokyo Astronomical Observatory of the Ministry of Education. But the argument that ‘a new organization should have a new name’ was also justifiable. ‘Astronomical Science Laboratory’ and ‘Institute for Cosmic Science’ were also discussed. The latter was considered some twenty years before. We wanted to manifest our attitude to make research of basic science wiping out the old image of observatory as an office of enterprise. But the inter-university research institute ‘Institute for Space and Astronomical Science (ISAS)’ that has started several years before had a Japanese name very like these two (literal translation is ‘Institute for Cosmic Science’). This institute was promoting space sciences.

Professor Kozai often said,

“I said that the word UCHUU should not be used in the Japanese name of ISAS.”

The Japanese word ‘Uchuu’ means entire space and time and is translated into English either as ‘UNIVERSE’ or ‘COSMOS.’ The word SPACE used in the English title corresponds to the space outside of the earth, or more precisely, extraterrestrial space. This word SPACE should not have been translated as UCHUU. But it was too late. Nothing could be done. After voting, we ended up with 'National Astronomical Observatory.' 'National Tokyo Astronomical Observatory' and 'Tokyo National Astronomical Observatory' were strong candidates until the last moment. In the United States, they put the name of the location at the top and call 'Kitt Peak National Astronomical Observatory,' or put the name of the field and call 'National Optical Astronomical Observatory.' In the University of Tokyo, 'Research and Education Center for Astronomy affiliated to the Faculty of Science' was created. It had three chairs and the Kiso Station.

The dinner party of the Baltimore General Assembly of IAU was held using the facility of the Aquarium and the Science Museum that are located on the two sides of the inner port facing the Chesapeake Bay. It was planned that the Space telescope (ST) is launched by that time. So, the IAU General Assembly was planned to be the festival of Baltimore because an institute for ST was created here. To the regret of all, the accident of the space shuttle 'Challenger' took place, so the launch of ST was delayed. The 2.4 meter diameter Hubble Space Telescope (HST) made by NASA of the United States and ESA of European Alliance had to rest in a hanger for some time.

When Professor Kozai and I were walking along the shore chatting with astronomers of other countries, I received a message from Tokyo saying,

"The request for fund of the large telescope for the next fiscal year was not admitted."

The message was not totally an unexpected one. But on hearing it, I felt to lose all my strength. I was working hard thinking,

"We can make it somehow upon transferring to an inter-university research institute."

I pulled myself together,

"Nothing goes smoothly the first time."

Uta was in Baltimore with me. She couldn't cheer me up although she saw me disappointed. She used to say to me reassuringly, "You can do it."

But she also was feeling gloomy. To both of us, the city lights of the inner port was too colorful. On the way to the dinner to celebrate the inauguration of Professor Kozai as the President of the IAU, the best I could think was,

"We can expect to succeed in inviting the General Assembly of the IAU. Will it help to promote the large telescope project?"

When talking with the acquaintances since long time from other countries, both Uta and I could talk about the telescope project proudly, but when we were only two, we began to think that we were doing something quite stupendous.

4.2

In 1988, cherry blossoms in Tokyo got in full bloom. It was the year when the General Assembly of the International Astronomical Union was held in Baltimore, The cherry trees in the Mitaka campus of the Tokyo Astronomical Observatory were in all their glory as if they symbolized a new hope.

In April that year, Ex-Prime Minister Mr. Yasuhiro Nakasone dropped in the Mauna Kea observatories after his attendance to a conference in Hawaii. He worked once as the Director of the Science and Technology Agency. So, he might have heard of our project from Mr. Toshio Komoto, a Diet-member. Mr. Komoto was an amateur astronomer whose knowledge often surpassed that of a professional. He knew recent astronomical findings. He himself did not attend the meetings of 'Group of Diet-members for Promotion of Large Telescope Project,' but his secretary was present on behalf of him. Once I had a chance to dine with him,

Cherry blossoms are in full bloom in the Mitaka campus of NAOJ in spring time. ©NAOJ but I could hardly eat food in answering his bombarding questions. He finally realized it and suggested to me, “Please enjoy your dinner.”

Mr. Nakasone gave me a polite letter of thanks when I sent him a copy of the book in Japanese, ‘Modern Astronomy Primer’ a few years ago. I wrote the book as an editorial board of Chuo-Koron Publishing Company suggested me to write. I was quite at a loss whether to accept his offer or not as I was in the labyrinth of the telescope project. But, finally I accepted his offer.

I thought,

‘I may not have time to finish the book if the telescope project starts.’

So, I started to write, but the work didn’t progress well. It was different when I translated, in my twentieth, the book of Professor Unsöld, ‘Modern Astronomy – Looking for the New Scope of the Universe.’ Somehow, I managed to make it a book. But I regretted as usual when the book was printed and published. Editor of Chuo-Koron commented,

“The book turned out to be a little difficult for ordinary readers.”

Therefore, the letter of thanks from Mr. Nakasone made me happy.

Hawaii is located between the mainland of the United States and Japan. So, sometimes, VIP’s of the both countries visit it. Conferences are also held there. As an activity during the intervals of conferences, golf is the most preferred among many recreations. But golf is not everything. A visit to the Mauna Kea observatories might have been a good intellectual recreation for him. But the mountain of 14,000 feet may make him tired although the visit may be a good intellectual recreation. Especially this is true for aged persons. But besides Mr. Nakasone, many persons of the political world including ex-prime ministers and candidates of the prime minister visited to see the site. We sometimes thought that the requests for the fund of the telescope project caused their visits. But it might have been only the convenience of scheduling their trip geographically and in filling the spare days. If I or other member of the preparation room was in Hawaii, we guided our VIP visitor. Sometimes someone had to fly to Hawaii to be a guide. Dr. Hall, Director of the Institute for Astronomy of the University of Hawaii, was enthusiastic in PR to the community. He often flew from Honolulu to the Big Island when the Japanese VIP visited Mauna Kea.

When all the staff were busy, Dr. Saeko Hayashi guided the VIP guests. Hayashi (whose maiden name is Suzuki) studied at the graduate course of the University of Tokyo and married her colleague astronomer Dr. Masahiko Hayashi. She worked at that time at Joint Astronomy Centre that has a 3.8 m United Kingdom InfraRed Telescope (UKIRT) and 15 m James Clerk Maxwell Telescope (JCMT) on Mauna Kea, Hawaii. When she was an undergraduate student of the University of Tokyo, she lodged close to my house in Suginami, and I asked her to be the tutor of my daughters when they were young. As I knew her since long time and she was my junior in the astronomy course in the university, I could ask her at ease to guide VIP's. Every time she undertook the job willingly, and her explanation at the summit impressed the visitors. Anyone who is a stranger to astronomy starts to think,

'It's magnificent. Japan has to build a large telescope here,'

once he/she visits the summit of Mauna Kea.

About three months after Mr. Nakasone's visit, an officer of Ministry of Education in charge of our issue visited the site.

'Can I expect that the possibility of realizing the project is now high because of reorganization to the National Astronomical Observatory?'

I visited Ministry of Education hundred times, but this was the first time that the officer in charge decided to see the site. I arranged my work so that I could guide him in Hawaii. I found, however, that he visited Mauna Kea on his way back from a conference held on the mainland. He said,

"I was told to see the site although nothing is yet decided on the funding of the project."

So, I could not overjoy on the fact that he came. The true reason of his visit was hidden in the mist. But it was a step forward that he came and saw the site. It was far better than nobody visits the site. We wanted to think that everyone who climbed up to the summit of Mauna Kea became our buddy. Once a senator of the United States visited the site. On his return to Washington, D.C., he sent a message to a certain VIP in Japan saying,

"I would recommend that you promote the JNLT Project."

This caused however a reverse effect that I was reproached by proper quarters.

National Astronomical Observatory was established but no prospect was given as to the funding of the large telescope. Instead, 'Fund for Survey of Large Observing Instruments' was allowed to the observatory. As the observatory became an inter-university research institute, this fund is given to the observatory as 'priming water' so that it can survey various instruments for its future plan. We were told,

"It is absolutely upon your decision if you include the large telescope in your survey with this fund."

In the National Astronomical Observatory, 'preparation room' of the large telescope project was created and it made documents for requesting the fund. 'Special Committee' was also created. Members of the committee were selected from universities and institutes and they were going to discuss the method of promoting the project and the engineering specifications. The Meeting for Engineering Investigation of Large Telescope was steadily studying and making survey systematically with definite targets. Main members of the project office were, Kodaira the chief of the room, the five members mentioned before, namely Yamashita, Nariai, Ando, Noguchi, and Masuyama, and Iye, Shuji Sato, and Nakagiri. There were many other staff to support these members. I persuaded Dr. Sato to move to NAO from the Kyoto University when he was abroad for long-term stay. It was clear to me that the infrared astronomy as well as the optical astronomy would prosper in the future. So, it seemed to me that having an experimental physicist as Dr. Sato was indispensable to our project. His simple and honest personality was attractive to me. His first task was to renovate the laboratory system of the observatory that was operated divisionwise by that time. A little later, Dr. Takuya Yamashita and Dr. Maki Sekiguchi joined us. Dr. Yamashita was going to study the infrared astronomy. Dr. Sekiguchi was doing high energy physics in the Fermi Laboratory in Chicago. He started the developmental study of the world's largest semi-conductor detector. Surveys and preparation works were proceeding steadily, but we didn't know if the essential condition of 'constructing abroad' would be allowed to us. It was still in the pitch darkness.

It was after the General Assembly of the International Astronomical Union in Baltimore and when we were going to feel the presence of Autumn that the annual meeting of the User's Committee of the Mauna Kea Observatories was held in Kona, Hawaii.

One person from Japan was allowed to attend the meeting as an observer. The first person to attend the meeting was Dr. Jugaku. I attended the following meetings for several years, so I was acquainted with the representatives of the member countries and the staff of the University of Hawaii.

An airplane flying to Hawaii takes off the Narita airport in the evening and arrive at the Honolulu airport in the morning. Time difference is five hours. An observational astronomer like me is accustomed to an inverse life style, that means sleep in the daytime and wake up at night. But in this case, I stay on a fixed place on the rotating earth. To my surprise, this is easier to overcome than the shift of active hours by the time difference. The first day of the User's Committee, I listened to the reports of the representatives of the member countries trying to wake me up with many cups of coffee and watching the Pacific Ocean through the window of the conference room. I had no duty of presenting an official report as I was an observer. I tried to recollect the necessary items that I should talk to the attendees during the coffee break and the dinner party. Every year, I was asked,

"Did you start constructing JNLT?"

and I had to answer,

“No, we still don’t know when we can get the fund.”

Such conversation was very hard to me. But I was relieved from the tired feeling upon hearing foreign astronomers say,

“So, you are still striving for it. I hope you can get it soon.”

In the daily life at the Mauna Kea observatories, I felt that people were working together. Here in the User’s Committee, I felt the sense of unity in a stronger degree. Those who maintain and operate telescopes, those who observe, astronomers who make research, their roles and nationalities are different to each other, but they have pride and sense of responsibility that come from the fact of working together at the frontier of mankind. Dr. Hall, the director of the Institute for Astronomy of the University of Hawaii has the nationality of New Zealand as the ex-director Dr. Jefferies. If someone was in trouble, everybody helped him. Yet, healthy competition was made in the academic field. Here, nationality didn’t have much importance. Of course, there were many items of troubles caused by the boundaries and nationalities such as employment or assessment of share of expenses. But these were low level problems that should be overcome.

Hawaii brings up citizens of mixed bloods from East and West. The society seems comparatively quiet in spite of so many races living together. Is it because of Polynesian and Asian bloods? Or the rich and gentle climate allows people tolerant lives? The hardships the people of Japanese ancestral origin experienced during the World War II are well known. Arizona Memorial towers at Pearl Harbor. It is quite natural that the Americans of Japanese ancestral origin who fought for the United States and Japanese who fought against Americans look the large telescope project in Hawaii differently. But I did not feel the difference in the Hawaii meeting. Many Americans of the Japanese ancestral origin attend the User’s Committee, and representatives of the local community are mostly Japanese by blood. I thought,

‘I will bring Uta here in the near future.’

Families of the directors of the existing telescopes at the summit lived on the Big

Island. Most committee members came to the meeting with their spouses. Although the spouses remained outside the conference room, every family were acquainted with other families.

The next day after the User's Committee, Saeko Hayashi and I guided Mr. and Mrs. Nihachiro Katayama to the summit of Mauna Kea. He was the President of the Mitsubishi Electric Corporation. He took the occasion of attending a conference in Hawaii to discuss US-Japan relationship to visit Mauna Kea. Mitsubishi Electric Corporation (MELCO) known by its many electric products was the very company that constructed the large radio telescope at Nobeyama, Nagano Prefecture. MELCO used the engineering know-how of making highly technical large antennas of its Communication Engineering Division in constructing the 45 meter Nobeyama Radio Telescope. MELCO also had the experience of constructing the precision tracking mounting structure of the 3.6 meter aperture Anglo-Australian Telescope made jointly by the United Kingdom and Australia. This precision tracking mounting structure was said to have the world's best performance. This high performance of the mounting structure was one of the main factors for this telescope to make many discoveries since its first light. MELCO was, of course, included in the list of the general survey made by the National Astronomical Observatory of Japan. Engineers of MELCO attended the Meeting for Engineering Investigation of Large Telescope since its start. But in order for them to attend the Meeting, we needed money. As it was not possible to foresee the funding of the telescope, we got the 'Fund for Research in cooperation with Private Companies' and the 'Fund for Experimental Research' of Ministry of Education to continue the basic investigations of the

View of the Hilo Bay with a cruiser. Beyond the sea is seen the slope of Mauna Kea.

telescope with them.

No salesperson of a big company will be happy when he gets an answer,

"One telescope within this century at the most,"

for his question,

"How many can we expect to sell the telescope?"

And the risk of the enterprise that bids for the primary contractor of such a large telescope with many developing factors can be said to be infinitely large. So, normally speaking, it isn't a profitable job. No company can undertake such a risky job without the decision of top management based on a thinking,

"We will do it so that we can contribute something to our country and to the human beings."

We still could not foresee the funding possibility. I encouraged myself thinking,

"It is enough if we can go one step forward."

Although I guided many top persons of big enterprises to the summit, I wished that Mr. Katayama understood the situation of the project. Although quite old, Mr. and Mrs. Katayama visited the site with light steps like youths. On the way back when we stopped at Hale Pohaku Mid Level Facility for coffee, he said,

"It seems to me that astronomy is quite interesting. It is an important science."

Saeko Hayashi and I looked each other hearing his words. Sun-burnt Hayashi smiled.

4.3

It was late in autumn. I was in Washinton, D.C. Leaves of trees of the street near my hotel in the regions where there are many embassies were starting to fall. It was a foggy day. The conference was going to be held at the headquarter of the National Science Foundation (NSF). It was after the Mauna Kea User's Committee Meeting in Hawaii and just before the International Conference for Large Telescopes to be held in Tokyo in November that I got the information of the conference.

I did not quite understand what's happening. I was told that a meeting like the meeting of the ministers of finance of the seven advanced countries that is called G7 is held every year. That meeting is on the science and technology and is more unofficial than G7. I was going to attend its working meeting. Later I learned that the meeting is usually called as 'the Mini-Summit on the science and technology' but its true name is 'the Japan-US-Europe Meeting of the persons in charge of science and technology.' Usually a representative and an officer in charge of the funding of the member countries attend the meeting. From Japan, a regular member of the Science and Technology Conference directly under control of the prime minister attends the meeting. In the Mini-Summit held in May, it was decided to set up a working meeting on the ground-based large facilities in the astronomical field. The US representative made the proposal and the European representative agreed with it. It might have been totally unexpected to the Ministry of Foreign Affairs and the Science and Technology Agency that a working meeting on 'the ground-based astronomical large facilities' would be held. The invitation to the meeting came to the Tokyo Astronomical Observatory through the Ministry of Education. It was decided that I attend the meeting. It was also decided that an officer in charge of the international affairs of the Ministry of Education would accompany me. This was something quite unexpected.

In the world history, the countries most prosperous economically and culturally carried the frontier of astronomy. The leaders of the European countries and US know that astronomy has the power of pushing the civilization of the human beings in a large time scale. They are aware that astronomy is one of the most important science among the basic sciences in this era when the science and technology is developing very rapidly. Constructing a large telescope has been always a challenge done with the engineering at the top front of that era and was always expensive. Astronomy is now one of the big sciences.

Sometimes the expense was too large for one country. So, the number of the telescopes made by international cooperation increased. Countries of the European

Continent gathered to create the European Southern Observatory (ESO) that promotes Very Large Telescope (VLT) Project which is a project to construct four large telescopes in Chile. The United States was proposing the Next Generation Telescope (NGT) to the United Kingdom and Canada. Japan was going to build a 300-inch telescope with the cooperation with Hawaii. As 'the Memorandum of Understanding' states, Hawaii provides the land and cooperates in constructing and maintaining the infrastructure, and the telescope itself is made solely by Japan and is operated by Japan. Among the next generation telescopes planned in 1990s, only the Japanese telescope did not express international cooperation.

It seemed to me that real international cooperation in the fields of the basic sciences of Japan was not feasible at all. At least it was true in astronomy, I thought,

'Astronomy is a field of science where cooperation of many countries on the earth is indispensable for its development, so ordinary international network in this field is thought to be well advanced. But it is difficult to start a joint enterprise with European countries or United States on equal footage basis. We do not have the infrastructure both in management system and laws that meet it. Cooperation with the neighboring countries may be easier because they are culturally close. But the political situations pose difficulty of another kind. In the past, most international cooperations in the field of natural sciences were either Japan joined as an addition to the organization led by Europe or US, or Japan asked developing countries to cooperate with an aim of educational effects. Japan does not have a close friend with whom it can create an international cooperation project, and its infrastructure is not sufficiently ripe.'

Thinking this way, this working meeting of the Mini-Summit seemed to pose a problem to us. The fact that the proposal came from US may mean that US aims to get an agreement of international cooperation for the project led by US. If this is the case, Japan will be put in a difficult situation. We are promoting the large telescope project but we are faced at difficulty in getting the fund. US may propose cooperation. If we can accept the offer, it's good. But this seemed to me more difficult than to get the fund for a standalone project. Japanese researchers in astronomy field would not agree to join as an addition to a project led by Europe or US because we were trying desperately to promote our own project. Joining their project should not help the astronomy in our country to make rapid progress. I thought,

'Our effort in transferring to the National Astronomical Observatory will not be awarded well.'

The meeting of the first day in the NSF headquarter started with a rather stiff atmosphere. The intention of the high-ranked NSF officer who attended the Mini-Summit was presented and the working meeting was requested to submit a report by the next meeting of the Mini-Summit that would be held in May the next year.

"What do we work on and what do we report?"

"It's on the ground-based large astronomical facilities. Artificial satellite projects like orbiting observatory are excluded. It should include radio telescopes and detectors of gravitational waves. But it should focus on the large telescope projects in the optical and infrared light. All the seven countries are concerned in promoting large telescope projects and the cost is tremendous."

"Do you suggest us to have some agreement on it? Aren't we here for that purpose?"

"Here we are looking for feasibility of projects. We wish to gather data from the standpoint of international cooperation."

"If you reach to a solution, is the Mini-Summit going to propose a plan?"

"I am attending this meeting because I was asked to be a member of this meeting. But I am not representing the astronomical researchers of our country."

"The Mini-Summit itself is a place of exchanging opinions among the top officers in the science and technology administration. The message from it does not have enforcing power. If a complete agreement is reached, it may happen that the report is reflected in the governmental policy."

There were four or five NSF officers present as the meeting was held in the NSF headquarter. I perceived that they were trying to make sure the discussions did not diverge. The attendees from other countries could not understand well the intention or the importance of the meeting and tried to continue the questions. The representatives from US, UK, Canada, and France were astronomers and I knew them since long time. The representatives of Germany and Italy were physicists whom I was also acquainted with. The agenda of the meeting was not fixed quickly. It was decided to take a lunch-break, to present the large telescope projects of the member countries, then to return to discussions of how the working group should work.

I got out of the building of the headquarter with the officer of the Ministry of Education, and sat at a table on the roadside of a restaurant. We were not acquainted with each other before coming here. In attending a conference on the East Coast like Washington, D.C., the afternoon of the first day is the hardest for me because of the long trip and the jet lag.

"This hamburger tastes good although it looks the reverse. Coffee is not good. Coffee at the breakfast was good."

"I agree with you. The hotel we are staying is too gorgeous. I don't feel home."

"Do you feel so? Me too. It seems to me that all attendees are staying in the same hotel."

We were making such pointless remarks bit by bit while still suffering from the jet lag. The sun was shining softly through the leaves of the trees lining the avenue. Finishing lunch, the officer left the table saying,

"May I leave here now? I wish to make shopping. I will be back to the conference room by one o'clock."

He must have been ill at ease talking with me.

I wanted to study the documents I had carried from Japan again as I had to present the Japanese project. When I returned to the conference room, NSF people and the representatives of Canada and France were talking over lunch. They were having hamburger and coke. They must have stayed inside and talked about the course of the meeting to aim. The afternoon session of presentation of projects started with French representative as the first speaker. He explained the VLT project which European Alliance is promoting from the sides of instruments, organization, and funding. It was emphasized that this project is a common project of the continental European countries and that the observatory will be located on the southern hemisphere. Funding is based on the agreed amount of money that each member country pays ESO every year. Expenses are payed from this fund according to the plan. I learned that there was a rule on the contractor which was not known publicly; In principle, the contractor should belong to the member countries of ESO, in other cases, it should be consulted with the committee. The total amount is four hundred million Deutcsh marks (= two hundred million Euros, approximately). I knew the number before coming here, but it is cheaper compared to that of the Japanese project. As the VLT project constructs four eight-meter class telescopes on the Andes plateau of Chile, the cost for one telescope is less than half the cost of the Japanese telescope.

The representative of Germany talked about the twenty five meter telescope besides the VLT project. This project needs many engineering developments. The representative of Italy talked about the project of the detector of the gravitational wave besides the VLT project. The instrument detects very small distortion of the space time with a laser interferometer that has two three-kilometer arms of vacuum tunnel. When the gravitational field changes rapidly in such occasion like collision of celestial bodies in the universe, distortion of the space-time propagates as waves. This phenomenon was predicted by Einstein with his general relativity theory. But it has not been detected yet by humankind.

The representative of UK reported that they decided not to do the gravitational wave detector. The eight meter class telescope project is well advanced and UK is looking for a partner of international cooperation. He brought a request to the meeting,

“The good site for construction should be regarded as the common property of human beings. Therefore, it is highly recommended that the administration takes an action to make foreign projects to use the site easy."

I admired him as the proposal was very pragmatic.

The representative of US presented the Next Generation Telescope (NGT) project which is a project to put four 300-inch telescopes on one mounting, and publicly announced that US is looking for partners to cooperate in promoting the project. The representative of Canada told that it did not have its own project but was ready to cooperate with an international project and join the observational activity with large telescopes in the next century.

I was the last to make presentation. I talked about the Japanese National Large Telescope (JNLT) project and also about the on-going engineering experiment of gravitational wave detector. I also explained, as other reporters did, the system of funding and the outline of the administrative organization concerned. Most of the questions directed to me were on the total amount of the project expenses of thirty to forty billion yen.

"Why is it so high? What is included in the cost?"

"Japan has not constructed three to four meter class telescopes yet. So, we have to create every infrastructure anew; experimental center for developing instruments in Japan, Hawaii headquarter, computer, lodging facility,..."

"How many percentage of the fund is spent for the telescope itself?"

"Seventy percent of the total cost, I think."

"It seems to me that your telescope is still expensive. How much have you spent in the developmental study.?"

"Almost zero. Oh, no. It may be about two to three hundred million yen, if everything is included. In Japan, once the fund is admitted, the entire project gets the money. Before that, almost nothing is payed."

"That way of doing costs more. If you pay ten percent of the total cost for the developmental study, You can save thirty percent of the total cost."

They were right, I thought. But at the same time, I did not think that was the only reason of high cost. The way of estimating the project cost in Europe and US is qualitatively different from that of Japan. As the officer of the Ministry of Education was at the same table, I will be in difficulties if the Japanese project is labeled here as high cost estimate. I urged what I was thinking always.

"I agree with you. But the cost estimate of a project in Japan is the sum of the maximum cost estimated pessimistically. Once you tell the cost, it will be impossible to increase the amount or get additional funds later. Contrary to ours, yours are the minimum cost estimated optimistically. Your cost is the amount that you can start with. At an advanced stage, you ask for additional funds. According to the results in your first stage, you can even double the fund. You can add this and that until the completion of the project. You have to recognize the difference of the funding system. It is no wonder that the pessimistic maximum cost is double the amount of the optimistic minimum cost."

I continued my arguments,

"The exchange rate of dollar to yen is determined by the merchandise traded by mass like vehicles, clothes, or foods. It is totally wrong to apply the same rate to the telescope that we do not construct only several per century. For these things, value of yen is cheaper by fifty percent or less. In summary, the cost estimate of the Japanese telescope is not unreasonably high."

Researchers seemed to have understood my arguments. But the attendees from the funding organizations took memo during my talk.

The meeting in Washington, D.C. lasted two days. It was decided that NSF makes the minutes of this meeting, the next meeting will be hosted by France and will be held in two to three months, and the future policy will be discussed there.

4.4

The second working meeting of the Mini-Summit was going to be held in Paris in

December. The officer from the Ministry of Education who accompanies me at the meeting was from the division in charge of the research institutes instead of the officer from the division of the international affairs in the first meeting. This officer had the experience of living in Paris and was active in such an international working meeting, I heard. So, I went to Paris feeling easy. The best thing for me was that he was in charge of the research institutes, so he knew the Japanese project that we were promoting well. He must have heard our explanation thousand times. His knowledge and understanding about our project gave me a sense of security. When we arrived at Paris, it was in the midst of unprecedented strike of public transportation. We had hard time going from the airport to the hotel designated. I may have been at a loss if it were not for the help of the officer who knew Paris well and his friend. The meeting place was in the ex-Paris Observatory that was located in the walking distance from the hotel.

As it was the second meeting, it was planned well. And four members of the working meeting attended the international symposium on the large telescope held in Tokyo just before the meeting, and we could exchange opinions. We held the symposium in Tokyo because we wanted to be one of the host country although the symposium was held in Arizona and Munich alternately, the cities where the US and European projects are based. In doing so, we also wanted that the Japanese project is evaluated and recognized internationally. In the symposium, I think, the attendees felt,

"Japan is doing quite well."

They also understood our situations that Japan joins the Mauna Kea observatories in Hawaii and construct and operate a telescope by itself. UK and US that were looking for some possibility of international cooperation with Japan gradually understood the difficulties that might arise from the special situation of Japan and the differences of systems. These things alleviated my feeling before I left for the working meeting of Paris.

The minutes of the last meeting was presented. The agenda listed the items to be discussed; recognition of the importance of large telescope project in the optical and infrared region and necessity of its promotion, the possibility and promotion of its international cooperation in its realization, opening up the construction sites and simplifying the immigration control and customs clearance, compatibility of the observed data and analysis software and promotion of making them open, etc.

The meeting went on in friendly atmosphere probably because of the meeting place of Paris and also because the items discussed became definite. Instead of coke, there were small bottle of wine. In the evenings, the attendees enjoyed their own cultural events. This working meeting was literally a working one. The officer in charge who accompanied me understood the meaning of the Japanese project in the world's trend. At the end of the meeting, we decided the share of the writers of the draft and that the next meeting would be held sometime after the New Year with UK as the host country.

On the seventh of January in the New Year, Emperor Showa passed away, and the era name was changed to Heisei.

From the New Year on, I began to receive the drafts to be included in the report. There was no problem with the general summary. It was difficult how to describe the Japanese project. I wanted a description stating a strong international support but the official standpoint of the Ministry of Education stayed stubbornly as 'researchers concerned are making a plan.' The member of the working meeting who was writing this part of the draft asked me to send him the expression to be discussed in the third meeting.

Writing the draft of the report took longer time than expected and it was only in March that it was decided that the third meeting would be held in Edinburgh, the capital of Scotland. It was decided that Professor Kozai, the director of the National Astronomical Observatory, would accompany us, the two members who went to Paris meeting.

A few days before the departure, concluding discussion on how to include the

Japanese project into the draft was made. The Ministry of Education claimed that my expression for the draft was 'too wishful.' They said

"The Japanese government has not yet decided whether it will do or will not. The expression of the draft should say neither more nor less so that the report does not interfere the domestic affairs."

The part of the draft where it states the European or US projects were clearer. The intention of the country to promote the project was stated and the international cooperation was requested. As to Japan, there was no way other than to write,

"We do not know whether we will do or not but we agree with the spirit of the international cooperation you are wishing for."

European Alliance has the funding plan of ESO. Each European country has an organization for scientific research. It is CNRS in France (Centre National de la Recherche Scientifique) and SERC in UK (Scientific and Engineering Research Council). A certain amount of fund is admitted to that organization by the government. NSF of US and the Max Planck Institut of Germany are similar organizations. If it decides to promote a project, the remaining problem is how to make up the annual funding plan. International cooperation is one of the technical problem in realizing the project.

In Japan, it is different. The Ministry of Finance has the power of judging the budget request. Until the budget is admitted, a scientific national project is only 'a concept of researchers in related fields.' There exist 'the Science Council of Japan' but it doesn't have the power to execute the budget. It is a strange organization. The Ministry of Education has the Commission for Scientific Affairs but it is an advisory body and has no power to execute the budget of its own. The Ministry of Education itself cannot state its wish until the budget request is admitted. If it can award us 'a fund for survey of large telescope project,' it means the wish of the Ministry is manifested. But it cannot do something for one big project before the Ministry of Finance admits the budget. It exceeds the authority of the Ministry of Education.

I envied the systems of Europe and US. They recognize that promotion of science is necessary for the development of the society in the long run, and have a system to secure the individuality that is the basis of the development. Some countries even have plural funding sources making competitive development possible. US and Germany are such countries. In US, there are NSF and the Smithsonian Society. NASA pours quite an amount of money into astronomy. Private foundations with the Carnegie Foundation at the head of the list have large economic power. Besides the Federal budget, each state has its own budget for scientific research. Every state universities has an observatory. In Japan, local governments, elementary schools, middle schools, and high schools have telescopes, but the telescopes for scientific use are owned only by two universities besides the National Astronomical Observatory, namely the University of Tokyo and the Kyoto University.

In Germany, too, the Federal and the local governments have budgets for scientific research. Moreover, there are many foundations that are aiding big scientific projects like Humbolt Foundation and Volkswagen Foundation besides the Max Planck Institut. They have a budget for astronomy. In Japan, a big project in the field of basic sciences like astronomy cannot get fund except from the Ministry of Education.

"How shall I write it? Shall we omit this part and make it a neutral statement? The working meeting admits the importance of the Japan National Large Telescope project that is developed by Japanese researchers. How is it?"

The officer who will accompany me to Edinburgh saw me with an apologizing look. We added a short explanation of the project in English and brought it to the superior officer. The superior officer who was experienced in the academic affairs and international matters read the English draft carefully and said,

"This is like flat beer. This won't make any effect. There may be no other way now."

He seemed to be desperate and also satisfied, but I could not read more from his countenance.

It rained in Edinburgh in March. The meeting place was the Royal Observatory. It was located on a hill called the Blackhill and showed its classical beauty. The draft was already circulated to the attendees. Item by item, the report was made up. For me, a meeting in Europe is better than a meeting in US because I suffer the jet lag less. But the city of Edinburgh was full of people because of a soccer game of UK against Ireland. Every hotel was booked full, and we had to change hotel every night.

The chairman, the director of the Royal Observatory, Edinburgh, announced,

“Please explain the part of the draft for the Japanese project.”

I was writing down the English draft for my explanation on a sheet of paper,

“The Japanese researchers plan to construct a large telescope in the optical and infrared light in the Mauna Kea International Astronomical Observatory. The Meeting recognizes the big significance of this project and recommends that the project is realized as soon as possible.”

I handed this paper to the director Kozai and the officer of the Ministry of Education[1] who were sitting next to me and whispered them.

“I will read this.”

To my surprise, both of them said ‘OK’ without being frightened. After my explanation, the representative of Germany commented,

“The words ‘big’ and ‘as soon as possible’ should be omitted in the draft.”

On hearing it, I thought that he was saying something hostile to me, but I immediately understood what he really meant. He continued,

“I wish that this report has effective power. It is very good that the Mini-Summit took up astronomy. It is better to make the report concise and firm. Rhetoric expressions should be omitted.”

I answered,

“I understand your point. Please omit those two expressions.”

After omitting those two expressions, the draft sounded more powerfully.

That evening, three of us were invited to opera theater by the director of tthe Royal

Observatory, Edinburgh. ‘Tristan and Isolde’ of Wagner was on the stage. The opera was quite lengthy. All of the family of the director were, I was told, fan of Wagner and all members including his son at the middle school age came to the theater. On the way back to the hotel after parting the director’s family, we stopped at a crowded pub. Those who ordered a large mug of beer were given a lottery ticket. We were told that the prize winner of ‘Hawaii Trip’ would be announced at twelve o’clock.

I told the officer,

“Get the first prize and come to Hawaii and see Mauna Kea.”

He answered,

“No, I can’t. As the report of the working group will come out in that form, I will be fired on my return to Japan.”

I could not guess if he was telling the truth or joking, but he seemed to be satisfied by himself. His words

“So, the telescope project will start,”

was answered by Professor Kozai’s words

“I am not sure yet, but it should start.”

Three of us toasted and left the pub. It was still raining and the sky was dark. The bases of big stone buildings in Edinburgh shined at the light of street lamps. I still remembered the heavy sounds of opera of this evening.

---

[1] Masao Honma

4.5

In 1989, National Astronomical Observatory started the soil survey of the construction site although the project was not funded yet. The preparation office of JNLT invited the staff of the Engineering Faculty and the Industrial Engineering Institute of the University of Tokyo and engineers of civil works in private companies as lecturers and studied the construction of the base of large buildings and the soil survey for that. The summit of Mauna Kea is a cinder cone made up of volcanic rocks and ash. We learned that there is no hard rock plate that are found in ordinary places no matter how deep we dig. When floating the concrete base on the soil, we have to study how fine the soil is and how hard the volcanic rocks are. There is a possibility that permanent frozen soil exist in deep layers. In fact, near the summit of Mauna Kea, there are a lot of round rocks scrubbed on the surface. They are the remain of glacier in the past.

I made a preparatory study and flew to Honolulu to negotiate with a soil survey company H&L in Pearl City. This company had already done soil survey for other observatories on Mauna Kea and was one of the company recommended by the University of Hawaii. As I drove seeing the Pearl Harbor on my left, I found the building in which H&L was located. The president was a Chinese American. He came with a female secretary, welcomed me, and showed me the testing instruments and facilities. After finishing the explanation of the outline of the company and main achievements, the negotiation started. Our budget is limited.

"As I explained our situation in my previous letter, I wish to make a soil survey for JNLT. I wish to have from you a standard proposal of soil survey."

The rather small president was listening with a smile but said rather unkind things,

"There is no standard in the soil survey. It can be different from one place to another. That is why you need soil survey."

I resisted,

"No, it is the summit of Mauna Kea. The site is only one hundred fifty meters from the site you made the survey last time."

After many debates, the president said,

"OK, the amount if we do the same survey as before, this we can write in our proposal,"

and asked an engineer to come. This engineer was a young and trustworthy looking man. He promised me to make out the documents by the next day.

With a thought of starting to touch the soil of the site in mind, the blackish Arizona Memorial in the Pearl Harbor which I had seen many times was afresh to me. An propeller airplane flew over it and went to the Honolulu airport.

On the next day when I reached the office of H&L, document of some twenty pages typed in small characters was prepared for me. It was full of numbers. I asked for time to read it. But I had to ask for explanation as there were many special terminology. After two hours, I understood that five survey items were included.

"How many days will it take and how much does it cost?"

I could not get what is needed most. The document listed unit prices. For the boring instrument that is carried from the mainland of US, it listed the mobilization fee, charge per day, engineering and lodging fee of the engineers who operate it, the storage and transportation fee per feet of the soil sample that are obtained by boring, testing fee, fee for the analysis of data, documentation fee, etc.

"How many days will it take?"

This will be the question I will be asked as soon as I return to Tokyo. If an officer comes with me to handle the contract work, it should be his work to read the details from such documents. But I could not ask an officer to come and make him do the work.

The negotiation should be done in English which is hard even for me who have the experience of living in US for several years and can use English in academic discussions and in daily life. And the customary practice is different. So, negotiation with foreign country is done by researchers. The situation seems the same in any university and research institute. A researcher does not know business work, so he has to study it to begin with. Because of such situation, the response of officers usually are,

"I do not like negotiation with foreign countries."

I repeated,

“How many days does it take?”

He answered,

“It depends on how the survey goes and how the weather is. Suppose that these five items are done as described in the proposal. We do boring at six places down to thirty meters. If we do not hit a rock and the survey is not stopped by bad weather, then it takes one month.”

I asked,

“How much does it cost?”

He calculated with his pocket calculator and answered an amount that is more than double the amount our observatory can afford to pay. I said,

“Our budget is less than half of that amount. Can you make it cheaper? I am afraid I have to get cost estimate from other companies.”

The president peeked at the paper and said,

“Which item do you wish to cut down?”

During the lunch break, I consulted an engineer of a Japanese company in Honolulu on personal relation basis. He advised me,

“H&L is a soil survey company. The work at the site like test boring is done by a subcontractor. Part of the sample analysis may be sent out to another company. I recommend you to ask a subcontractor to come with you to H&L and listen to their explanation. There, you choose items one by one.”

He also said,

“But it won’t come to half the price no matter how you reduce items. Two items among the five can be done later. It can be done by the construction company just before the work starts. It isn’t too late that way. The other thing to reduce the cost is the number of places and the depth of boring.”

“Our observatory wish to know how many days it takes and how much it costs.”

“In US, lump sum contract is not usually used. It accompanies risk. If they do not finish the work within the period described in the contract, they have to pay the penalty. If you insist on the lump sum method, their estimate will include the risk hedge that is quite costly. They can estimate how many days it takes as far as the favorable condition prevails. They can give you cost estimate for that case. The rest of the payment depends on the results. When rocks are found, or when a hurricane comes, the cost increases. They are quite reasonable. It is also necessary to supervise the work. You don't need to pay for the work not accurately done. Have you asked a consultant to supervise the work?"

His explanation was new to me. I may not have been right in thinking that it's OK to negotiate a soil survey company like H&L in Honolulu or on the Big Island. So my first trip of negotiation ended.

I contracted a soil-survey consultant before my next trip. The consultant had the head office in London and had worked for observatories in the UK. It makes a proposal for the survey items, sends engineers to the site two times to supervise the work, then check the report of the survey. The money prepared for the work becomes less because of the payment to this consultant. But I was told that the cost for the main work can be made less by a large amount if a consultant supervises the work. Besides the consultant, it was also necessary to contract a surveyor. The engineer of the consulting company said to me,

"Make the number of boring minimum and do it only at the necessary places. In order to fix the place, it is necessary to have the position of the building with a precision of several meters. Survey is necessary anyway, and it is also necessary for the sub-lease contract of the land."

The money for the soil survey company decreased again.

In my second trip of negotiation, I visited H&L with an agent of the consultant. As we asked in advance, H&L made engineers of the subcontractors to be present in the negotiating room one by one at the right time. The work took time, but the accumulation of the cost was done steadily. In the afternoon of the second day, days and the cost for the work were finalized. It was close to our budget as the consultant expected.

"I agree with the accumulation. In Japan, contract of this sort is done by lump sum method. Can you make it such and such amount in so and so days?"

The president looked up the ceiling then down to the document playing with his fountain pen by his fingers.

"Rocks and hurricanes should be kept aside of the lump sum. These are beyond control. Other things, I agree to include everything in the lump sum. But I add extra period of twenty percent, that means extra cost, too."

"What do you have other than rocks and hurricanes?"

"It may happen that mobilization of machines from the mainland be delayed, or machines have troubles."

"That should be faults on your side. Arrange and check things not to have such troubles. Also these are within the responsibility of the subcontractors. You do not need to pay for them."

Atmosphere got awkward. As we have worked out the results, we may have reached a conclusion if the negotiation is done in the Japanese way. I thought I could accept his arguments and leave his office, but the agent of the consultant was strong at this point as if his work can best be shown here. We left the office saying,

"You think over it by tomorrow before we get back here."

The next day, we had a telephone call from him and was asked for one more day. We made an appointment with another soil survey company and visited it. I worried,

"H&L is clearly better than this company as they have experience of working on the summit of Mauna Kea. I should have accepted his proposal. What should I do if he says no."

The next day, I got a proposal from H&L,

"Increase the period with the cost kept fixed. How about it?"

We rushed to his office and started making the contract document. The rest of the work could be done by the admin division of our observatory.

The survey was done quickly. It took a few days before the map was produced, but there was no obstacle to start the soil survey as the center point of the building was finalized. But the mobilization of machines from the mainland was delayed. After the start, the axel of the boring instrument was broken. But the weather was stable and we did not hit a rock. The site work finished almost as scheduled. In the preparation room of the observatory, we bought a video-camera, so we could see the images at the site. The boring was done down to thirty five meters at the center of the building that is the point where the center of the reinforced concrete column on which the telescope is put and buried. After some three months, we got the report of the soil survey. It said that the soil layer was softer than we anticipated from the survey results of the neighboring sites. Preparatory design of the building and the soil improvement design started immediately.

Parallel to the soil survey, we made other surveys of Hawaii. Dr. Nariai and Dr. Ando collected detailed data and interviewed personnels of other observatories for various informations. Survey of the laws and regulations was a big item. This survey never ended. We had always something for which we lacked informations; tax systems, procedures for the custom clearance, application for construction of building, application for registering as corporation, insurance, school, housing, medical care, etc. We bought Revised Hawaiian Statutes published by the Hawaii State government. Other than the systems in US and in Hawaii, we studied main corporation in Hawaii, ports and their facilities, transportation route of big cargo, and electric and communication facilities. The results of survey was made into a report. From this phase on, we had help from the Society of Japanese Ancestral Origin in various ways. Important members of the Japanese Society were interested more in improving the economic situation than in the astronomy. Anyway, they were friendly to us because we were going to build a large telescope. We refrained from being overfamiliar because of our nationality. Also from this time on, we often asked the

General Consulate of Japan in Honolulu for help. No matter how the official view of the Ministry of Foreign Affairs is, the Consul General and other personnels of the Consulate General had good-will toward that the Japanese large telescope is built in Hawaii. They always helped our activity in Hawaii actively.

We spent more time on the survey of systems of the existing foreign observatories. What structure of personnels do they have? With what status are they sent to Hawaii from their home country? Are they hired in Hawaii? What is the salary system? What visa do they have? Is there any restriction in renewing the visa? Such a survey usually starts with getting an appointment. Then meet the director or the director of the administration division of the observatory and listen to their talk and get copies of documents. But after each interview, we realized that we failed to ask some important question. Sometimes, our understanding was not complete. I am sure that we have annoyed them very much. But they were patient and kind. When we repeated the same question many times, although they were patient enough, they said,

"I explained it to you the other day."

On such failures, we almost lost courage to continue. After two years, we understood the management of observatories. In order to construct and operate a telescope similar to JNLT, we need an organization of the size of fifty to sixty personnels. Some observatories hire them in Hawaii through the Research Corporation of the University of Hawaii (RCUH). When a personnel is despatched to Hawaii from his home country and stay there for a long period, most of the diplomats' rules are applied. There are two workplaces, namely the summit and the headquarter. Most engineers work at the summit in turn. Engineers are hired by their specialty and the unit of the term of the contract is two or three years. The despatch from the country also uses two or three years as the unit of the term. We made the same survey on the observatories in Chile. These data of survey were used in planning the JNLT observatory.

By regulation, it was not possible to pay the expenses of these frequent trip to foreign land with the budget of the observatory or with the research funds from the Ministry of Education. Besides the trips for survey, we had to make foreign trips in order to attend the periodical User's Meeting of the Mauna Kea observatories or the working meeting preparing for the draft of 'the Operation and Site Development Agreement (OSDA).' The Memorandum of Agreement (MOU) between the University of Hawaii and the National Astronomical Observatory was extended several times although we could not secure the construction fund. 'Toyota Foundation' helped us when we were in such difficult situation.

In 1989, I happened to read the public advertisement of research fund offered by Toyota Foundation. 'Exchange of different cultures' and 'High-tech engineering society' were the keywords. Advertisement seemed to be directed toward the social sciences. Natural science and engineering seemed to be out of scope of the research fund.

'But,'

I thought,

'there were two reasons when I decided to construct the telescope. If 'astronomy' is the right foot, then 'internationalization' is the left foot. Most of the survey we are doing now are necessary because the construction site is in foreign land. It is not relevant from 'astronomy'.'

'How about the title, 'International Fusion in the Field of High-Tech Basic Science — Cultural and Institutional Problems arising from Construction of the Large Telescope in Hawaii.' Basic Science, specially a big project, has always an aspect of 'for the human beings.' Because of this, it extends beyond the border, and can become the motive power of cooperation and cultural exchange. Astronomy is the top runner of this sort.'

Thinking this way, I wrote the application form in one day and sent it to Toyota Foundation. The first application was for a pilot research project. If it goes well, I can advance to the main research project of two years. After quite a period that I submitted the application, I got a message from the Toyota Foundation,

'Submit additional explanation sheet concerning the significance of this research.'

Later, I learned that there were serious discussions in the selection meeting or the boards meeting concerning my application.

'The survey is done for a national project of a national research institute. Expenses of foreign travel of such research and survey should be paid by the Ministry of Education. A private foundation won't pay for it.'

This was a right argument.

'But the total amount of the budget of foreign trips of the Ministry of Education is very small now. For most officers, foreign travel expense means money used for sightseeing tour or fact-finding tour. In the field of academic research, researchers go abroad to work, so it is necessary as a part of research fund. The money described in this application is certainly a little different from research trip fund. But this project should be supported.'

One of the supporters was the board chairman Professor Souichi Iijima. Professor Iijima was consecutively the president of the Nagoya University and Hiroshima University and knew pretty well how researchers in universities struggled with the small amount of foreign travel fund. His persuasiveness realized the adoption of this project. The project started a little bit late, but Toyota Foundation gave us, in four years starting from November of 1990, a research fund close to ten million yen to our pilot project, two years main project, and its extension of one year. Every year, I had to present a report at the meeting of the achievement of the research project and submit a written report for the proceedings. But the use of the fund was left entirely to researchers. Main members were Dr. Nariai, Dr. Ando, and I.

I reminded me of the fund in aid of researchers by 'Sakkoukai' created with the pocket money of Mr. Soichiro Honda and Takeo Fujisawa that I received when I was a young assistant. There was no restriction on its usage and Uta and I appreciated it very much as we had just returned back to Japan and were economically suffering.

For the second time, I felt the value of the private fund that is more flexible than the governmental fund restricted by many regulations.

‘Such a flexible fund is certainly necessary to carry out the JNLT project.’

I planned to create such a foundation and started a study for it parallel to the promotion of the JNLT project.

4.6

In the preparation room of the observatory, we did the paper work necessary for the budget request with Mr. Noguchi as the chief of the group; How many kind of works there are in carrying out the observation project of JNLT, how many personnels are requested for it, etc. It was necessary to prepare the system to support it in Japan. Observatories of European countries and US have big experimental facilities and machine shops used for the developmental research. These are indispensable. They should handle rapidly evolving semi-conductor detectors and the electronic signals from them, so they should be equipped with electronic instruments, computers, and communication facilities. I got anxious as I studied the necessary items,

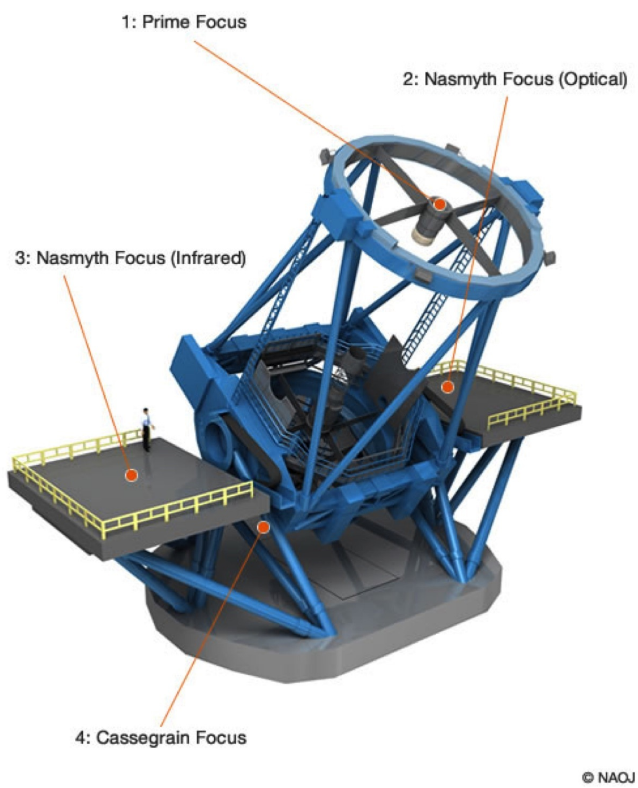
‘Can they really be realized?’

But making JNLT without these facilities would be like ‘Kamikaze bomber.’ I reminded me of the arguments we had ten or so more years like a nightmare,

“First, we should make a three meter class telescope in Japan.”

In 1989, ‘General Concept’ of the project was almost complete. It included every aspect of organization, facilities, and operation. At the same time, the outline of the telescope itself and the dome and building were ready and we could go into detailed design. The telescope optics was designed by Dr. Nariai. The main optics was Ritchey-Chrétien system, and the primary focus and Nasmith focus were also available. Light reflected by the main hyperbolic mirror placed at the bottom of the telescope tube forms image at the primary focus. If another small hyperbolic mirror is put near the primary focus, light is reflected back and forms image after it passes through a hole at the center of the main mirror. This is the Ritchey-Chrétien focus. If a plane mirror is inserted before the image is formed to reflect light forty five degrees, light is led to the fixed optical bench outside of the telescope tube and forms image there. This is the Nasmith focus. The available space near the focus is the smallest at the primary focus and the largest at the Nasmith focus. Thus, Nasmyth focus allows installation of a pretty big instrument.

The dome building is cylindrical and rotates with the telescope synchronized with the telescope motion. It is unmanned. Control of the telescope and the dome is done in a separate control building. In the lower part of the building will be installed the huge aluminizing chamber. Most plans were drawn by Professor Yamashita and Mr. Noguchi. The general survey of companies capable of contracting construction or manufacturing telescope parts advanced. It became clear that there is no candidate in Japan for manufacturing the 8.2 meter mirror. For the upper structure of the dome that rotates synchronously with the telescope, we also could not find candidate in Japan as the work required long experience.



Subaru Telescope has four foci, namely 1. Prime focus, 2. Nasmyth focus（optical）, 3. Nasmyth focus（infrared）, and 4. Cassegrain focus. ©NAOJ

“I wanted to make the entire telescope with the Japanese engineering. But it doesn’t seem feasible. Do you agree with me?”

“As far as engineering is concerned, we can make it. But if the project is regarded as a business, it won’t make profit. Also transportation of such a large item is difficult in Japan. Location of factories in Japan is not favorable for it."

"O.K. Let's decide that our telescope is made not only under the Hinomaru flag (Japanese flag). We will be the main team. Let's use the best engineering technique from all over the world."

The feelings of the staff changed gradually.

There were many companies that were on friendly terms with our project since our general survey made five years ago. Each company was keenly interested in it. As the fund is governmental, there is a bid before placing order. We do not know which company gets the bid. Staff of the preparation room wanted to get information from companies without restriction and get cooperation. Company people tried to tell the selling point of his company and get some promise from us.

"Professor. Who would commit to this project for all his life?"

Some sales engineer asked such a straightforward question. The project lasts ten years from its start. And we do not know when the funding is made. After more than ten years of working with the telescope project, I realized that I am over fifty years of age. Abilities of young professors and associate professors were evaluated by the company people so that they can evaluate the feasibility of the project. They didn't say it to me, but it was clear that they gathered informations for evaluation from many people of neighboring field or from the staff himself.

Certainly, JNLT project as a national project was similar to big civil works or ODA projects. VLT of ESO may be the same. A national project doesn't start even if the researchers' wish is unanimous. Engineering support and economical effects should be considered. I started to think,

'O.K., the Ministry of Education observes us on such a side, too.'

A big science does not dwell in the pure academic activity only, but it is related with the industry, economy, and politics. Thinking like that, I began to understand what the Diet-member whom I met said to me.

"What is it used for?"

This was the question I was often asked. As the project spend a big budget, it should be ‘useful’ for taxpayers. The world history tells clearly that the development of astronomy played a big role on the civilization of human beings. Determination of geographical position through observation of stars enabled making maps, and determination of time with stars promoted the technique of clocks and enabled making calendar. Such techniques of determining position and time developed the art of navigation and with the knowledge of ‘the Earth is round’ led to the ‘Age of Great Voyage.’

Detailed observation of positions of planets led the change from geocentric theory to heliocentric theory, changed the world view of human beings and developed navigation technique and opened up the road to the modern era. ‘Cosmos’ or ‘Universe’ that astronomy studies is the space and time never experienced by human beings. Its recognition process brings us knowledge that is not anticipated by human beings. Because of this, conversion of creative way of thinking is called ‘Copernican.’

“What is the universe?”

“Where are human beings and the earth in the universe?”

These are the fundamental questions of human beings since the old times. The universe continued to be the most challenging target of the intellectual activity of human beings. The results of the intellectual activity happened to be useful for the human beings. Such is the basic science.

Observation of celestial bodies by Galileo and discovery of the law of universal gravitation by Newton led to the creation of modern science. Astronomy is the source of natural sciences. It is indispensable to build a scientific world view that is concerned with philosophy and religion. Study of the motion of the Moon based on the Newtonian mechanics developed the theory of orbit of artificial satellite as is represented by the studies of Professor Kozai, and it was the big motive force in this era of space development. The technique of determining position and time as is represented by ‘car navigation’ that uses GPS satellite is the results of many astronomical researches. It can be said to be a hi-tech product.

The results of research on the closest star, the Sun, are now used in various ways in the daily life. Helium that is used in the cryogenics was first discovered in the Sun. So helium took its name from the Sun (helios). The study of energy source of the Sun together with the study of atomic nuclei gave birth to nuclear reactor, then led to the study of thermal nuclear fusion that does not produce radio-active waste. Shining stars are 'natural thermal nuclear fusion reactor.' For the study of high energy magnetized plasma that is necessary for developing thermonuclear fusion reactor, the solar surface provides a big experimental laboratory. Study of explosive phenomenon called 'flare' is necessary for the maintenance of space communication and security of astronauts.

Accompanied with the explosion, strong ultraviolet and corpuscular radiation occurs that hurt humans and disturb the earth's ionosphere. Most important thing with the Sun is that it provides energy of the earth on which human beings depend. The sun is increasing its thermal radiation although at a very small rate. This has a decisive effect on the long term temperature increase of the earth. We are going into an era when problems of energy, natural resources, and natural environment have to be solved in the scale of the earth. It will be necessary for human beings to understand the universe as the largest environment and recognize the position where they are put. Basic science like astronomy becomes useful in a time scale of fifty or one hundred years. It doesn't aim at an actual profit. Because of that, it has a power to create entirely new things. Its impact is as effective as a body-blow. It contributes as the motive force to academic civilization if viewed in a short time scale, and it contributes to the formation of civilization and culture in a long time scale. But it is not 'useful' in the meaning that Diet-members use.

European and US scholars say the same thing concerning their big project in the field of natural science. In US congress a question was asked,

"Is this project useful for the defense of our country?"

The scholar answered,

“No, it isn’t. But it is useful to make our country more worth to defend.”

‘A country worth to be defended,’ it is a civilized country respected by other countries, and is treated as a friend country. A country that has economic power, and is capable of carrying out a mission of guarding the common property of human beings. If Japan in the twenty first century is going to maintain the economic prosperity peacefully, it is inevitable that Japan make the power of civilization grow.

Another frequently asked question was,

“Why is it necessary that our country makes such a large telescope?”

As you may have understood by the answer of the previous American scholar, promotion of astronomy is a task of the entire human beings. Therefore, in all the era efforts have been made by the highest civilization of that time. Countries of high economical, technical, and cultural level shared the frontier of astronomy. To be such a country is an honor. Such a country is respected internationally and is expected to be a leader. In Japan, this is not easily understood. Japan that tried to ‘catch them up, overtake them’ since the Meiji Era and suffered a setback by the Second World War, restored its economy and is now called a big economic country. But it has not come back to a big cultural country. The Diet-member’s question resides in a more actual world.

“Don’t they make this kind of telescopes abroad?”

“Yes, they recognize the importance of such telescopes and are promoting their projects.”

“Then ask them to let you use the telescope. You can pay for it.”

Astronomer’s answer is as follows;

“If a compact disk of Berlin Philharmonic conducted by Karajan is available, are we OK without an orchestra in Japan? Don’t you wish to make sound yourself? It’s not to receive culture. It’s to create culture.”

Question continues.

“Why do you make it in Hawaii? You can try it in Japan. I can help you to get land in my prefecture.”

I can answer this question clearly. The cost performance is extremely bad if the geographical condition of the location is bad. The worst question to answer is,

“Why do you need fund next year. Why can’t you wait ten or twenty years in exploring the universe that is wide enough that light takes fifteen billion years to go across?”

I answer,

“European countries and US recognize the importance of such a project and trying to promote as early as possible.”

“From the world view of the twentieth century to the world view of the twenty first century, we are required to renew our world view. Time is moving rapidly. In order to make contribution appreciated internationally, we have to hurry up. Japan is expected to be the top runner among the large telescope groups that are aiming to construct a large telescope on the northern hemisphere.”

While we were repeating such questions and answers, each interested company was trying to make Diet-members and officers of related Ministries understand the situation. Their standpoint is the promotion of the project which is the same as ours, but it is natural that in their case, stress is put in securing budget and getting the contract. Although I knew the difference between them and I, I often wished,

‘It may have happened that company people were moved by our zeal. Diet-members and officers, too.’

One day, I made up my mind and went to the Ministry of Finance where one of my friends since long time worked as a high-ranked officer[2]. I had a feeling that he might give me an appropriate idea. As an old friend of mine, he often listened to my talk of JNLT project and he had interest in astronomy, too. He asked me straightforwardly, “How do the officers of the Ministry of Education behave?”

“I feel all of them think that it would be good if realized. But as there is no preceding example to construct and operate a property worth several tens of billion yen in foreign territory, this is a barrier for them.”

“Well, but there is no law to forbid it.”

These were the words I totally did not expect.

“O.K. There is no law to forbid it!”

“It depends on the case. But in your case, the key is if the officer in charge makes up his mind or not. Let’s go to the officer in charge and ask him how he thinks.”

We went downstairs and met the officer in charge and the head officer. After some conversation, I learned that these two persons knew the JNLT project quite well. The officer in charge said,

“First of all, we cannot say anything before the Ministry of Education requests the answer for a question.”

This is a matter of course. He continued,

“The Ministry of Education has a big budget. So, they can manage to squeeze out money for this project if they think thoroughly.”

He continued further,

“As the way of spending the budget, I don’t think it’s a bad one.”

The officer in charge said as if it’s a soliloquy probably because my friend and I were standing in front of him. His words seemed to be expressing his true feeling, and not because of only sympathy. After this day, I decided to tell the Ministry of Education that officers of the Ministry of Finance think ‘There is No law to forbid.’ I also got the feeling that officers in the Ministry of Foreign Affairs think the same way as the officers in the Ministry of Finance.

Around the time when the report of the Mini-Summit was complete, the political situation in Japan was highly fluid in the liberal democratic party that had the political power. Just before the examination of the important items of the budget request for the fiscal year 1990, we got an information,

‘Some powerful Diet-member interferes the JNLT project.’

The officer in charge of the Ministry of Education suggested, although he did not clearly say,

‘We have to put up the examination of the JNLT project.’

Of course, many budget requests in the Ministry of Education compete each other. Such competition exists in the academic field, and also among the big projects in the field of natural science. Among the big projects, JNLT project was supported by wide variety of people although it had an unsolved fundamental problem of ‘construction in the foreign land.’ I almost felt an atmosphere that people think,

‘Soon let us admit the budget request for it.’

It was just at that time. I was attacked by a miserable feeling of beaten up as if cold water was thrown on me. All of a sudden, people in the government and administration started not to say anything. I tried to think of Diet-members whom I met in various meetings and committee meetings. But it didn’t help me anything.

‘Something is hidden to me; something proper to the political world such as relative strengths of Diet-members or their relations to the vote regions. Was construction in foreign land fatal? Or is there some international problem?’

I was almost desperate, but some people encouraged me,

“You cannot do anything now, you don’t need to. JNLT project is for all the people in Japan. This interference came from an individual. There must be some way of solving the problem.”

Meanwhile, the political situation of Japan moved rapidly. Prime Minister Uno had to resign in no time. In August when the Voyager II of NASA was approaching the Neptune, Prime Minister Kaifu came into power. Mr. Toshiki Kaifu is a relative of Professor Norio Kaifu of the Radio Astronomy Division of the National Astronomical Observatory, and had worked as the Minister of Education. He knew big projects in the field of astronomy, so he had a tough side when debating.

It was Mr. Toshiki Kaifu who asked me a severe question in one meeting,

"Tokyo Astronomical Observatory made a forty five meter telescope in Nobeyama, Nagano prefecture. Observatory people said at that time that astronomers would see through the edge of the universe with it. Why do you ask for an eight meter telescope this time."

I answered instantly,

"That is a radio telescope. The present one is a telescope for the optical and infrared light."

But it seemed to me a bad answer. It sounded like a child's words claiming for this toy and that toy. I continued immediately,

"In the radio wave, we see cloud-like celestial bodies of low density while in the optical and infrared light, we see celestial bodies of high density like stars. From clouds are born stars, and stars return to clouds after explosion. In order to get a dynamic world view, both are necessary."

But this answer may not have been understood because it was too specialized.

Nobeyama Cosmic Radio Observatory provided its forty five meter radio telescope and large radio interferometer to all researchers in Japan and got many scientific results. Specially, in the observation of molecular clouds in the 'star forming region' where stars are born in mass, it discovered new 'interstellar molecules' with its 'Acoust-Optical Radio Spectrograph' that has very wide band-width. In the super-thin cosmic space, miraculous molecules are born. Radio-astronomers of Nobeyama in cooperation with researchers in the chemistry field conducted theoretical and experimental study and solved the nature of those molecules. Long chain-like molecules that can never be found on earth were found, and it was thought that there is a possibility of these molecules develop into organic molecules. Such frontier research attracted young researchers and applications for observing time from abroad did not come to an end. So, the question at this meeting had a point.

Time passed while we were anxious, but finally luck turned for our favor. It was decided that the new Prime Minister Kaifu, ex-Minister of Education, visit the Nobeyama Radio Astronomical Observatory. Exactly speaking, Mr. Toshiki Kaifu with his family was going to drop in the observatory during his vacation on the foot of mountain of Yatsugatake. Anyway, the Prime Minister is coming just at the time when the National Astronomical Observatory is going to realize the JNLT project. As a matter of course, Director Kozai and I, and a high ranked officer of the Ministry of Education went to Nobeyama the evening before his visit. That night, we argued about the future of the observatory while drinking, and the next morning I suffered a headache because of hangover. The Prime Minister came and I was in the group of his tour of the observatory, but it was hard for me to climb up to the shoulder of the forty five meter large radio telescope. I regretted,

'I may not be able to profit this occasion to promote the JNLT project.'

The tour of the observatory ended as scheduled and we sat at a table of the conference room for tea break. There JNLT project was presented. After the presentation of the observatory, the Prime Minister Kaifu said in his personal capacity,

"Why don't you continue to promote the project?"

Those who were in the room said something like,

"Thank you very much. We will do our best to realize the telescope to meet your expectation."

And a souvenir picture was taken.

At this time, the Ministry of Education and the persons concerned had a consensus as to bring the budget request of 'the Survey Fund for Construction of the Large Optical and Infrared Telescope' to the Ministry of Finance, we later learned. But staff of the preparation room including me were not optimistic. Every year, during the time of budget request, we were busy answering the questions and making out documents as admin division needed them. In August, we waited nervously expecting that the Ministry of Education brings our budget request to the Ministry of Finance. In such period, the staff of the preparation room stayed in turn in the observatory until midnight. I sat in front of a large table in the room and waited meditating. When meditation didn't help me from getting irritated, I took out brush and paper from the drawer and practiced calligraphy. Mine was not a skilled one, but it helped me to calm down and helped the staff to beguile.

Chinese ink and a writing brush helped the author to calm down his uneasy sensation.

---

[2]Toshio Osu

4.7

The Lake Ritzen in Berlin was frozen and was white covered with snow. Big trees surrounding the small lake extended branches as if they were trying to receive snow flakes coming down from the gray sky. I had a touch of cold, but Uta was in high spirit as she came back unexpectedly to the capital of Germany. It was only two weeks ago that we decided to come to Berlin at the year-end.

In Japan, at the beginning of the year 1989, Emperor Showa passed away, then the prime minister changed. So, it was a restless year. On the other side of the Eurasian continent, a bigger move started this year. Liberalization policy of Gorvachov, President of USSR, who tried to break up the standstill of the communism society, was learned immediately by the people of the eastern Europe helped by the wave of information-oriented time, moved their sentiment, then resulted in an explosion of eager wish for liberty. On September 11, the government of Hungary, who could not continue to control people who wish to go out to Austria wishing for liberty, opened up the gate at the border. Countries of the eastern Europe that was prosperous when the Hapsburg family was governing were swallowed by this wave one by one. The East Germany was not an exception. President Hornecker resigned on October 18, and on November 11 the blockade of Berlin was lifted and the wall that separated the East and West Germanies lost its power. On 28 of the same month, Alexander Dobchek, the hero of the tragedy of 'Spring of Praha,' came back to the post of the Chairman of the Federal Congress of Czechoslovakia. And it was announced that the Brandenburg Gate, that was the symbol of separation of East and West, would be opened.

Uta and I reminded us of the time of almost thirty years that passed. It was when I was in the Indian Ocean on the way to Germany to study astronomy on board of a French cargo-passenger boat 'Cambodia' that I learned the news of blockade of Berlin. I proposed Uta in October 1962 in Berlin that was separated into east and west.

'The Brandenburg Gate closed since that time will open and citizens of East and West Berlin come and go freely. 'Avenue of June 17' of the West and 'Boulevard of Unter den Linden' will be united and become one street.'

As we were imagining the feeling of the citizens of Berlin and the people of Germany, we could not help come and see them.

Hotel See Hof on the shore of the Lake Ritzen still keeps the atmosphere of the ancient Berlin. Two of us were taking breakfast leisurely in a café by the side of terrace that command the lake covered with snow. Aromatic coffee, round bread just baked, sausage and cheese, many kinds of jam, we could eat whatever food at whatever amount we wanted. As I was sipping hot coffee, I felt that I began seeing the exit of the tunnel that seemed to me endless. For these seven or eight years, Uta and I did not enjoy such leisured hours together. Since I settled down to work seriously on the large telescope project, most of the private life was sacrificed. Uta didn't know what to do with me who was in gloomy mood. I was tired out with surveys and getting a consensus on the project before it is officially brought up to discussion. Every night when I got home, I just ate supper and slept without much conversation. Uta knew it was because of the telescope project, so our quarrel never became violent. But it would have been no wonder if Uta thought of divorce. It was quite rare that we went out together. When we went out, I got tired quickly and got in bad mood. I was not sick, but it was certain that I was not strong enough. It was certain that I caught cold in this Berlin trip because of my weakened physical strength.

"Our children have grown up well. It seems to me a wonder that they grew up without much trouble. I'm serious."

Uta said satisfactorily looking the Lake Ritzen through the terrace window that was apt to become hazy. I said,

"It's been a long time,"

and sipped the cup of coffee. It might have sounded half as words of thanks and half words of apologize.

Brandenburg Gate

Actually, the life in Japan is certainly better than that of twenty five years ago. Water system and sewage system are completed and flush toilet is used commonly. Roads are paved although the sidewalk is not always good. Stations and towns are now clean although they were dirty before. People are wearing smart clothes. Supermarkets are found everywhere. Merchandises are plentiful. People can afford now better lives. Stores are closed on Sundays. On weekdays, they close the doors early in the evening. So, it's a big difference compared to twenty five years ago. What Uta complained about improved in ten year's time. Our second daughter Annette protested against the sex discrimination in the class of domestic science in the middle school. It was abolished later. In our family, we do not have much savings, but do not have loan either.

That night, the town of Berlin shining with the lights of Christmas was in an extraordinary excitement. The wave of people was moving slowly toward the Gate of Brandenburg. In the crowd where we could not stir an inch, each had a candle in his hand and mourned for the victims. It was cold. Uta and I were pushed by the people in the rear toward the gate, then pushed again to the return route. We prayed, then returned to our hotel and watched TV in our room.

'While Uta, a German girl, and I, a Japanese boy, married and brought up three daughters, East and West Germanies hated each other. How many innocent people did lose their lives here?'

Soon, as the church bells were ringing, the door of the Gate of Brandenburg was opened. Citizens of East and West ran up to each other. Some climbed up the wall and jumped down to the other side. Crowds of people were moving. Soldiers of East Germany trying to control the crowds were shown in close-up.

The next morning that the Gate of Brandenburg was opened, I got a telephone call from the preparation room in Tokyo.

"The draft plan for the next fiscal year was announced unofficially. Fund for the survey of construction of telescope is included in the draft. The budget request for the first year of the two-year project of the solar radio telescope was also admitted."

I believed that the project would be O.K., but on hearing the message, I had the feeling of relief. The fact that the survey fund with the official project name was included in the draft meant that Japanese government manifested its intention of promoting the project. On the other side of the phone-line, he continued,

"Professor Norio Kaifu of radio astronomy will join the telescope project. He will move from Nobeyama to Mitaka."

For the staff of preparation room who fought the lonely fight of long time, this might have been a story not acceptable immediately. But I had another stance.

Two big fields of observational astronomy 'radio' and 'optical' are complementary to each other, but two competed in some phase in the past. So, interchange of personnel between the two was not smooth. This time, while optical astronomers promoted the telescope project in Hawaii, radio astronomers promoted the construction of ‘solar radio telescope.’ Professor Kaifu was one of the leader of the latter group. He was also the top personnel of the Nobeyama cosmic radio astronomy group that constructed for the first time in Japan a big observational facility, offered it to all the researchers in Japan, and got results of the world frontier class. He was a graduate of the Basic Science Department of the Cultural Science Faculty. This made him a little different from the graduates of the Astronomy Department, Faculty of Science, I thought. I wanted that he joins our project since long time. The telescope project of Hawaii is far bigger than the cosmic radio telescope project of Nobeyama, and is a hard project. Its success is only possible with all the power of astronomical fields in Japan. Bigger a project is, various persons of talent are needed. Its success is promised only if persons of various talents and of various ways of thinking get together and work for it. Participation of various persons means good things as well as strains in the human relations. But the time of ‘closed competition’ is close to its end. Now, we have to look for ‘open cooperation.’ I consulted unofficially with the researchers in the radio astronomy group. I thought

‘Persons concerned, Prof. Kaifu himself, the director, all of them must have made up their mind catching the best timing.’

I understood the feeling of the staff of preparation room well, but wanted that they overcome this wall. I prayed

‘In order to complete the project, I have to let more and more persons of different talent and different way of thinking join our group.’

I hanged up the phone saying,

“Let’s discuss about it after the New Year.”

Uta noticed something occurring in me and asked,

“What happened?”

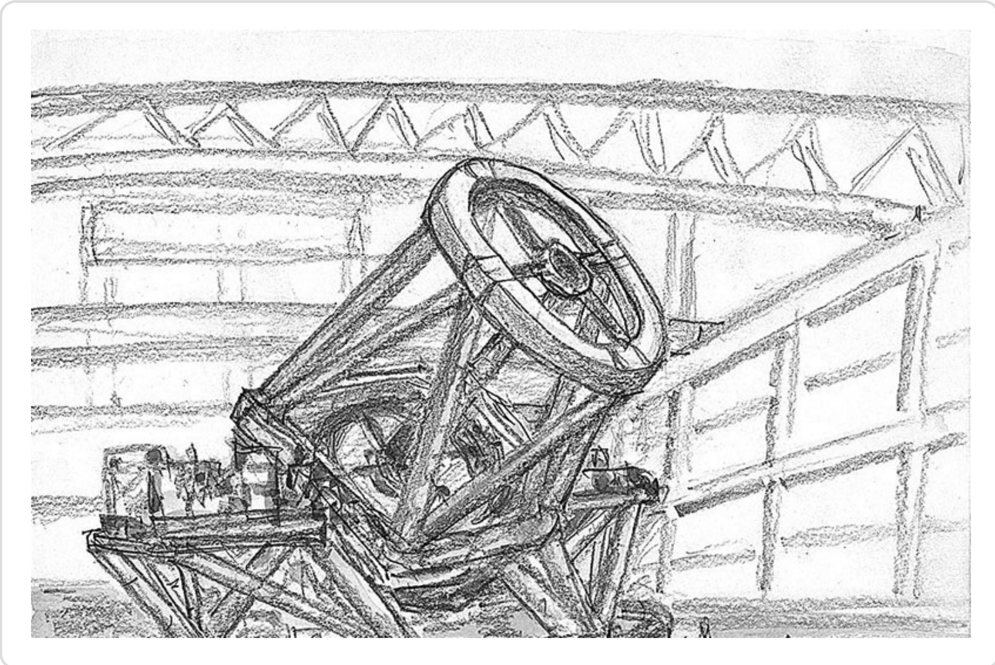
“No, nothing important whatsoever. A message came from Tokyo telling that the survey fund was allocated."

I answered only that and uncorked a bottle of champaign.

[Published] **Keiichi Kodaira/Kyoji Nariai**: **2016**, NAOJ-Books : Makali'i in Hawai'i.

Chapter 5

Let's Create an Eye of Mankind



5.1

The preparation room of the National Astronomical Observatory got active as the Survey Fund for Construction of the Large Optical and Infrared Telescope was appropriated. The fact that the Survey Fund was appropriated showed that the Japanese Government decided to promote the project. Setting up a system in the project so that it can meet the work for the budget request for construction and related works caused a big change in the structure of the preparation room. The step of including Professor Norio Kaifu as the chief of the preparation room that started to be discussed from the last year-end created a great stir. It took long time before every member understood its necessity.

I, who promoted the large telescope project for my life, was already fifty three years old. The construction project that we requested for budget was an eight year project. It was impossible to shorten the period. From the points of view of engineering and also budget request, it seemed that its extension should be taken into account but cutting the period was impossible. That means the telescope would not have been completed before my mandatory retirement. The National Astronomical Observatory succeeded the rule of the affiliated institute of the University of Tokyo of the mandatory retirement age of sixty for researchers. That the completion of the telescope comes after my retirement was clear when the survey fund for construction, and not the construction fund, was appropriated last year. When I heard last year in the director's room the official notice of survey fund, and not of the construction fund, I didn't know what to say for a moment. The large telescope for which I made efforts sacrificing researcher's life of ten years would not be completed while I am working in this observatory. Persuading myself

'It's unavoidable,'

I decided to expedite the personnel plan that I had in my mind for some time.

Almost at the same time as Professor Kaifu joined us, Dr. Hiroshi Karoji joined the preparation room as its manager. Dr. Karoji used to be the first student of the graduate course I supervised in the department of astronomy of the University of Tokyo. After he took his master's degree, he went to Europe upon my recommendation. He became a student paid by the French Government. During the disturbances in universities, he proved to have a talent of politics. He had an ability of negotiation of his own. His stay in France was first planned for two years, but he was there for nearly twenty years. I asked him to come back to the observatory and help the large telescope project.

I myself became an advisory staff with a title of project scientist and worked mainly on external and general issues. Those who have worked for many years as the main members of the team, namely Professor Yamashita, Drs. Nariai, Ando, and Iye, were going to be heads of teams on specific tasks such as optical system, dome and buildings, observational instruments. Professor Yamashita also started to write a book 'Reflecting Telescopes' that included results of studies and surveys on the construction of the large telescope. This book was later published at his retirement by the University of Tokyo Press. Making up the final documents for the budget request required enormous amount of work on engineering and administrative matters. In addition to those who were working on these matters in the preparation room, namely, Mr. Noguchi, Mr. Nakagiri, and Mrs. Masuyama, I had to ask Mr. Akihiko Miyashta in the Mitaka campus and Mr. Kiichi Okita of Okayama Astrophysical Observatory to work together with them. Mr. Okida was an observatory personnel, at the same time used to be an active member of a theatrical circle in Okayama region. He gave up his theatrical activity and moved to Mitaka.

As the 'Fund for Construction Survey' was appropriated in Spring, the Large Telescope Project was reviewed in the Space Science Division of the Commission for Scientific Affairs of the Ministry of Education. At the same time were reviewed the Solar Radio Telescope of the National Astronomical Observatory and Super Kamiokande project promoted by the Cosmic Ray Institute of the University of Tokyo. The latter was a project to detect proton decay with a larger instrument than the existing Kamiokande, and its cost was estimated to be 10 billion yen. The cost of Solar Radio Telescope was 2 billion yen, and the cost for our large telescope in Hawaii was 40 billion yen.

Kamiokande is an ambitious experimental instrument with its aim at detecting proton decay that elementary particle physics predicts. It has a large tank filled with pure water which is observed by a colossal group of photo-multipliers for 'Cherenkov radiation' that is emitted from the traces of particles created by the proton decay. As the lifetime of proton calculated by the theory is quite long, the number of expected detection is small although the tank is huge. As the Cherenkov radiation is contaminated by other photo-electric phenomena caused by cosmic rays and high-energy particles generated by radio-active material, noise supersedes signal by a large amount. The instrument is installed deep below the ground-surface of Kamioka mine in Gifu Prefecture so that the noise decreases. In the process of removing noises, 'neutrino' coming from outside of the earth is also counted.

Neutrino particles originating from the Sun posed an important problem. Only a fraction of the neutrino radiation calculated with the internal structure of the atomic reactor Sun was detected. Is the experimental instrument not correct? Or, is the theory of neutrino theory wrong? Or, is the central temperature of the Sun lower than the calculated temperature based on the surface conditions and the assumption of quasi-thermal equilibrium? If the last hypothesis is correct, we will meet something horrible in the future. If the effect of the low central temperature reaches the solar surface, the earth will have a severe glacier period. Researchers of Kamiokande paid great attention on counting the solar neutrino.

In 1987, a supernova appeared in the Large Magellanic Cloud that is a small and young galaxy attached to our Milky Way galaxy. This emitted a lot of neutrinos and a part of it was detected by Kamiokande. The Great Magellanic Cloud is at the distance of one hundred fifty thousand light years away. The explosion that occurred one hundred fifty thousand years before is observed by human-kind now. This was the first detection of neutrino of cosmic origin from other than the Sun.

When a star as an atomic reactor exhausts its fuel at the center and fails to produce the thermal gas pressure to support its inner wall that is pulled inside by gravity, 'gravitational collapse' occurs. At the moment of the stellar death, its central part collapses and changes into a neutron star or a black hole. At the same time, its outer part is blown away by an explosion. The enormous energy emitted at this instant is observed as a 'supernova' that heralds the 'finale' of a star. Neutrino of supernova origin is emitted at this moment of the gravitational collapse of the core of the exploding supernova, it can be identified with certainty by its position on the sky and the observed time. Its analysis greatly contributed to probe the internal structure of stars and also the process of 'gravitational collapse' that had hitherto been studied only theoretically. Super Kamiokande was planned as an instrument of higher sensitivity after the success of Kamiokande's supernova detection. After the discussion of the Space Science Division of the Commission for Scientific Affairs, materializing work to include 'astronomy' into 'basic science field to be promoted intensely,' in the budget request of the Ministry of Education.

In the preparation room of the National Astronomical Observatory, documentation of budget request for the next fiscal year was to be finalized at a high pace.

"Let's make the aperture eight meter,"

Professor Kaifu opened up the argument.

"O.K. I think it's O.K. now,"

I agreed immediately. No one of the preparation room staff was against.

As the aperture of the large telescope started as '300-inches,' studies have been made with a specification of 7.5 meters throughout the project. European and American projects was going to adopt an aperture size of eight meters, a round number based on the metric scale. So, theirs were bigger than ours. We were uncomfortable with this situation, but it was not easy to change the number in the budget request already submitted. If we were going to change the aperture size, we had to work on the change of the engineering design, the addition of the cost, and the preparation of justifiable reason for the change.

When explaining the Japanese large telescope project that had a nickname of 'Nana-han,[1]' I said,

"It is true that the aperture size is a little smaller than the European and American ones, but we are going to design and make the telescope to have sharper images than theirs."

It seemed to me a good philosophy. I also wanted to resist the current of the time to compare everything by the size; the Eiffel Tower vs. the Tokyo Tower, the Empire State Building vs. some other building. In Japan since the Meiji Era, it was important to lead the world by one meter or even by one centimeter. My 'Nana-han' theory lacked persuasiveness. It was not clear how sharp the images would be with an aperture that is smaller by half a meter and why the same sharpness of images would not be attained with eight meter aperture. Above all, 'the world's largest' lifts everyone's spirit. It is not easy to prove the world's best by quality, but 'the world's largest' by aperture size was clear to everybody. Engineers, researchers, administrative officers, officers of the Ministry of Education, Diet members, all of them reacted the same; they were not against the change of the aperture size to eight meter. But the increase of cost due to the change was a negative factor. ‘Cost should be kept the same.’ This was necessary.

Accumulation of cost showed that the change to eight meter affected everything, the cost of the building, too. Therefore, it was necessary to cut the cost in other places admitting trade-offs caused by the shift of cost. But labeling ‘the world’s largest’ lifted the spirits of the staff, engineers, and administrative officers, resulting in a motto, ‘The best telescope as cheap as possible.’

In the budget request for the fiscal year of the third year of Heisei submitted before the summer, the telescope was described as ‘eight meter class.’ In the same document that went to the Ministry of Education, the organization to promote the large telescope project and the system for operation of the telescope after completion were described. At some phase of this process of submitting the request, ‘Center for Information Processing and Communication’ was removed from the document while no one in the preparation room knew it. After our survey done for long years, we reached a conception that ‘Center for Instrument Development and Experiment’ and ‘Center for Information Processing and Communication’ were infrastructures essential to support the large telescope. It was quite disappointing. Every European and American observatory has the former as a facility to develop instruments. It was clear to have it in order to change astronomy in Japan that lacked recognition of being an empirical science. On the other hand, the latter might not have been a facility clearly indispensable for the project at this phase. But our survey reached a conclusion,

‘The progress of the techniques of information processing and communication that includes computer techniques is rapid and it is expected that these techniques will be the most important after ten years when the telescope will be completed.’

It was expected that the techniques of information processing and communication will determine the fate of the astronomical observation project. I felt it through my experience of studying galaxies, but this plan of the second center was simply removed.

On August 24, 1990, we received many messages. Besides the formal announcement of the decision of the Ministry of Education by the director of the observatory and the director of the administrative division, we received many fax messages saying,

"Congratulation! The Ministry of Education decided to submit the budget request of the construction of the large telescope to the Ministry of Finance. Six hundred and fifty million yen is appropriated in the first fiscal year. Your efforts through long years are rewarded."

We received many telephone calls, too. Dr. Nariai, Dr. Ando, Mrs. Masuyama and I had a small lunch party in a restaurant close to the observatory to celebrate the start of the project. To my pity, I could not catch Mr. Noguchi for this party.

I thought,

'The project was delayed by one year. But I fulfilled my responsibility that I carried for many years. But enormous work is waiting us.'

I was happy and at the same time, anxious. But I felt relieved anyway for the moment.

Autumn came. The East and West Germanys were united in October. Uta and I attended the commemoration ceremony held in the German Embassy in Tokyo. In November, Mrs. Thatcher who led the United Kingdom for a long time handed over the chair of the prime minister to Mr. Major.

The year 1990, however, started with sad news. On January 2 on return from the year-end Berlin trip, the husband of a German lady who was the best friend of Uta passed away abruptly. He was a singer, and his birthday was the same as Uta's.

Another sad news followed. My colleague in the observatory Dr. Katsuo Tanaka passed away on January 4. He was my junior at the University of Tokyo by several years. He was talented both as a theoretician and as an experimentalist, and was specialized in the solar physics. He was the leader of the team of the first Japanese satellite to observe the Sun, 'Hinotori.' He got ill when he was working hard analyzing data. He was still striving for research while fighting against illness, but finally he gave way to his illness. I cannot describe well how he himself and his family felt sad, but the Japanese astronomy suffered a lot, too. Promotion of the space astronomy that I once wanted to carry on but had to leave was on his shoulders. We were very much discouraged by his death because we wanted him to take the leadership.

Professor Keizo Kai who was the leader of the 'Solar Radio Telescope' project whose construction started that year got in bad health in his fiftieth and had to stay in hospital. He fell victim to incurable illness of unknown cause. Direct cause was not known, but it seemed to me that the state of the disease got worse because of the hard work of promotion of the project. In the past, Professor Haruo Tanaka who took the leadership of construction of the Large Cosmic Radio Telescope passed away the next year of completion. He was only a little above sixty.

It did not seem to me to be coincidences that the leaders of such big projects passed away early. With our large telescope project, things went to good direction since the last year, but if such move was delayed by one more year, I might have lost my health and power of will, and resigned because I was to be blamed of this unrealistic project. Catch copies of 'world's best by all means' and 'with all our might' that dwell in our souls seemed to me things that should not be with scientists.

---

[1] A motorcycle of 750 cc displacement has a nickname of Nana-han. 'Nana' is seven and 'han' is half.

5.2

As soon as Mr. Ackerman, the President of the Corning Glass Works, arrived from New York by his airplane, a ceremony celebrating the start of the eight meter class mirror blank for the Japanese National Large Telescope was held.

After the budget for the fiscal year 1991 passed the Congress, the main contractor who will have the responsibility of construction of the entire telescope project was put out to international tender. It was already summer. When Mitsubishi Electric Corporation (abbreviated as MELCO hereafter) got the bid and took the responsibility of this difficult task, I could not help feeling greatly relieved. As the tender was made international, I was prepared to face a case of a foreign company becoming the main contractor. However, I was sure it would bring a lot of troubles or cumbersome works. Specifications were fixed. However, our telescope was an instrument which humankind makes for the first time in its history, and the location of construction is in foreign land which Japan had never experienced of. Tests for overall performance of the telescope will be done only after the telescope will have been assembled at the summit of Mauna Kea at the height of 4,200 meter above the sea level. For the entire system that needs judgements at every phase and good risk management, it was clear to me that we need quite a large overhead, i.e. extra man-power, to proceed the project if we were doing it with an American or European enterprise. MELCO, the successful bidder, chose Corning Glass Works as the fabricator of the mirror blank after having studied the engineering specification of the National Astronomical Observatory of Japan that the support is made with holes on the backside of the blank. Judgement depended on the fact that a mirror blank of completely amorphous structure is stronger against the internal stress.

The ceremony was held in a room of Glass Museum of Corning. The first and unused blank for the 200-inch mirror of Palomar was displayed there. On one wall of the room lit by dim lights, the five-meter mirror was shining in yellow-green color. I could see clearly the honeycomb shaped hollows on its backside that was invented to make the mirror light-weight. Those who attended from NAOJ were Dr. Ando, who was in charge of the mirror from the start of the project, and myself, and from MELCO Mr. Chikao Kinoshita, the project manager. Those who attended from Corning Glass Works were the President Ackerman, Vice President, Director of the Canton Factory where big items are fabricated, the person in charge of the eight meter mirror project, and so on. About ten persons in total were surrounding a table. Everyone had the countenance with feeling of relief and tension mixed.

Feeling of relief was the consequence of the end of hard period when preliminary survey had to be done without any positive lookout for the fund for the project for the past several years.

‘How many times have I visited this company?’

I told the same story to every company I visited,

“We are striving for getting the fund in the next fiscal year. If you plan to get the bid for the Japanese mirror, you should schedule your furnaces prepared for that. Do not put yourself in a position unable to start the Japanese job immediately with long term work running there.”

The construction lasts eight years in total. And I, as a scientist, wished to complete it as soon as possible. Europe and America started projects of telescopes of the same class. Companies willing to make large ultra-low-expansion glass blank were not many. If they are occupied by the jobs of other projects, delay of a year or two will be there easily. Makers were also using harsh words;

“How sure can you expect to get the fund for the next fiscal year? 50 percent or 80 percent?”

“What are the obstacles that delay the project? What is the total budget for this sort of academic research? What are the projects concurring?”

“Can’t you get R&D [2] fund so that we can proceed with our preliminary survey?”

“I can understand what you are wishing for. But, finally, the first-come is the first-served. We will do our best, however, the surest road to that is to get the fund before other countries get theirs.”

Such were the conversations every early summer before we started negotiation with MESC for the funding.

“To our great regret, we could not put our project into the budget for the next fiscal year. But we will do our very best to put our project into the budget coming next.”

Every late autumn, I repeated the same request. It was no good to find reasons of our failure in getting the fund. It would have been worse to try to get their sympathy for the delay of our project. What I could only do was to talk passionately of the life of stars, of the world of galaxies, relations between the humankind and the universe,

"How wide will become the dream of human if we have this large telescope! What will be our viewing point looking ourselves from the Universe? From the engineering point of view, how highly technical and challenging the project is!"

As to the last remarks, engineers of glass industries felt that it is true than we did. However, what we could say might have been said by astronomers of other countries. So, I used my trump card;

"This is the first project for Japan. I believe that Japan should become a country internationally more open. Japan should carry a project of its own that can contribute to the benefit of the human kind. Now, we do have neither laws nor institutions to accommodate such international projects. I am trying to make Japan to take a step forward for the internationalization through this telescope project."

My listeners might not have understood me. If he thought the following way, I am very much obliged to him;

'I do not see exactly what this man is saying. But it seems to me that he has an extra reason to make this project real. That may make profit of our company in the end.'

The contract was made after many such occasions. Therefore, it was quite natural that people of both sides had the feeling of relief. But it was only for the first few minutes, and the atmosphere surrounding the table was of more tension than relief. Dim lighting and high ceiling created an atmosphere that it may be quite natural if the ghost of late Dr. Hale, the man who gave birth to the five meter glass blank, appeared from the side of the blank which was shining at the wall in yellow-green color.

President Ackerman eloquently talked as a true businessman of American first class company;

“It is our privilege that Corning Glass Works that gave birth to the 200-inch Palomar telescope, is now going to produce the mirror blank of the world’s largest telescope. We will do our best in making the finest mirror blank with every possible effort of all our company. I hope that our accumulated engineering know-how and the results of our most modern research will suffice your expectation. In order to achieve that, we will construct a new large furnace in our Canton factory near the St.Lawrence river. Also, we asked the retired engineers who worked for the Palomar mirror to come back to help us. I wish that the astronomy in Japan will prosper with the National Astronomical Observatory of Japan as its center, and contribute to the benefit of the World and the Humankind.”

I do not remember what I said exactly. I felt that I talked everything I could talk of at that time. As a man representing the owner, I should have talked about what I expected about the delivery date or quality of the product. But I think I only talked on ‘The Edge of the Universe.’

The Gulf War that started when the Iraqi army led by the President Hussein invaded Kuwait was put to an end in the month of February of this year by the concentrated missile attack of the American Air Force. In the summer, the Soviet Union collapsed. Gorbachov, the flag-bearer of freedom and liberation, was purged from his president’s post and President Yeltsin was leading the confused Russia.

Uta and I compared the confusion of the united Germany with that of Russia. Uta was teaching at the Tokyo Institute of Technology for a long time while I was not exactly aware, and she had sent many students to Europe from her seminar by that time. She volunteered to be a mediator between the universities in the German speaking Europe and Japan. She who thought,

‘Now is the time to start interchange of personnels with the universities in the liberated old East Germany,’

visited universities in the old East Germany trying to make new bonds with Japan, but she found that the situation was desperate. Construction and removal of artificial wall had severely hit the economy of the East and West beyond expectation. Universities in the old East Germany that were liberated from the control of ideology lacked persons of talent not to speak of facilities. Various personnels of the West were flowing there and it was in confusion. To Uta who was deeply disappointed learning the present status, the increase of letters from the listeners in the old East Germany to ‘Japanorama’, a program of Radio Japan, NHK international broadcasting, was a great joy. She wrote answers diligently. Then many letters came to her. When Uta talked about the start of the Japanese large telescope project, many letters came saying,

“I didn’t know that Japan had such a project.”

Although the amount was only six hundred and fifty million yen, the start of the first year of the eight-year project made everyone’s heart in the National Astronomical Observatory and also the astronomical world in Japan lighter rapidly. In the project room headed by Professor Kaifu, a meeting was followed by another to finalize specifications and to exchange opinions with company personnels. As to the news media, we were hitherto modest in talking to them and were careful in every word we used. But we were allowed to make press release with triumph. Works for the budget request for the next fiscal year were done with such high spirits, but the prospect was not always good. Economy of Japan in 1980s overheated and broke down, and the collapse of the ‘bubble’ started. The total budget is forty billion yen and the appropriated fund for the first fiscal year is only six hundred and fifty million yen. We could not overjoy. Too heavy budget would be postponed. We had to work slowly.

“We have to modify the future budget plan,”

the officer in charge of the Ministry of Education worried.

Officers in charge in the headquarters in Kasumigaseki such as the Ministry of Education change posts every two or three years. It is so from the top to the bottom.

An officer has to decide if a difficult project is set to start while he is in a responsible post or let his successor judge about it. The officer to succeed him cannot throw away the project that his predecessor let started. In a certain country, the country policy changes as the president changes. Even a big academic project may be stopped or modified. In today's Japan that is led by bureaucracy, governmental projects have some kind of stability and continuity. It happens both in good and bad situations. It is difficult to make his predecessor a bad fellow, so the successor make all his efforts to continue the project. All the officers from the top to the clerk who were in charge of this large telescope project took great care of it. An officer in charge worked so hard for the project that his health broke down.

We studied many plans, but we finally had to change the period of project from eight-year to nine-year. In the budget request of the second-year of the nine-year project, however, the start of construction at the summit of Mauna Kea was included. I was glad thinking,

'Now, our project is going in full-scale.'

On the other hand, it was clear that the completion comes after my retirement. I tried not to think about it too much. I tried to persuade myself,

'I may not be able to work in an active post until the completion of the telescope. But I am satisfied if our staff can complete 'Our Dream' shared by many people.'

As the budget request of construction on Mauna Kea was going to be submitted, I visited Iwanami Film, Ltd. I wanted to have 'records in images' and studied about it. In the office of Iwanami in Yushima, President Fujise and Mr. Seki in charge of sales were waiting me. The meeting went on as I expected.

Personnel in charge of the project changes. Works are done in many places on the earth. I thought that all of them should be recorded as 'the Telescope Project.' I consulted many people. I could not guess how much the total cost would be. There was no hope to get the governmental fund for that. At first, I asked for ideas from several people whom I was introduced through broadcasting companies and Japan

Film Association. I listed up the stages of work for the project years. The interest of the observatory stayed on recording the efforts of researchers and the details of difficult engineering stage. But most advisor were interested in the 'events.' High-light scenes, so to speak. We argued a lot about it. The argument ended with,

"I will make what you wish to have if you order to make it. But who, do you think, will see it. You can put it in a storehouse and be satisfied. A film maker, however, cannot work without assuming spectator. Nobody will spend money for such a nonsense product."

It became clear that the cost is between one to two hundred million yen. When documenting a project, it is necessary to film everything. It seemed that more than ten times of filming is necessary than what is actually used in the final product. Moreover, in this category of scientific recording, filming is done everywhere in many ways; in the field, or indoor close-up, filming of large structures, etc. I was informed that high resolution of images is important. Handy video-camera was not good enough in view of resolution. Filming with 16 millimeter camera was recommended.

I thought,

'There is no other way than to ask Iwanami Film that is known to have made many scientific documentary films.'

There might have been other possibilities. But I got an appointment with Mr. Fujise, the president of Iwanami Film, and met him. The president of Iwanami Film was a rather small mild looking gentleman. I told him of my motivation and the status we were put as far as filming was concerned, and waited his answer.

Mr. Fujise told,

"I cannot answer immediately. I will submit a proposal after meeting my staff."

About a week later, I received a simple proposal. It said,

'First of all, it is necessary to make a contract between the observatory and Iwanami to make the basic plan. Five million yen is sufficient for this year. From the next year for a period of ten years, fifteen million yen is necessary per year for filming in Hawaii and other locations. This is the cost for filming and making them as film material. In the third or the fifth year, a part of the material is edited to make so-called promotion films. They are short ones of five minutes or so, and are used for public relation activities of the project and also for collecting fund for filming. Final product is a movie of thirty to forty minutes that includes the results of observations after completion of the telescope. This requires another thirty million yen. At this phase, with a little more extra money, it is possible to make films for grown-ups, for youths, and for schools.'

I began to understand what filming pictures is, but the problem was the fund for it. I got consent from NAO that the contract for the basic plan is O.K. But I did not have any prospect for farther work. Iwanami gave me useful suggestions that were based on their experiences;

'Companies that got the contract are interested in this kind of records of engineering. Companies can use them for their PR and also for in-house journals. If NAO can get agreement with the contracting companies and Iwanami for filming project, it can achieve its aim with only the cost of management for filming.'

I thought that was a good idea, and met persons in the sales division of companies. But I got answers,

'As the bubble collapsed, cost for public relations and in-house journals were decreased.'

I asked them,

"It's a ten-year project. We have reached the start after ten-year work. The telescope will work for thirty or fifty years after completion. I ask you not to decide with the present status of your company."

It took almost one year before we came to an agreement. We had to cut many items, and postpone the arrangement for the film editing. Copyright was complicated, but Iwanami would handle it. Filming work started with the soil treatment of Taisei

Hawaii on top of Mauna Kea as the first work.

[2]Research and Development

5.3

The name 'Large Optical and Infrared Telescope' was certainly long. It was good as a name for an item of official governmental fund, but it was not familiar to all. Internationally, we used 'Japan National Large Telescope,' but its accronym JNLT was not easy to pronounce. So, it was agreed as,

'Construction has started. Let's invite suggestions for a nickname for the telescope.'

We received three thousand five hundred entries. A selection committee was created. The most numerous was 'Big Eye.' This name was used when the Giant Telescope of Palomar was born, so it was rejected. The next numerous was 'Ginga[3].' But a Japanese X-ray satellite had the same name and was still active. So, this was not selected, either.

Many committee members thought,

'Yamato Kotoba[4] is most suitable as this is the first big scientific facility that Japan constructs in foreign land.'

Some thought of a word with alphabets, but those who were for the Yamato Kotoba were stronger. Before the invitation for the name was announced, 'Mahoroba[5]' and 'Mandara[6]' were thought to become strong candidates, but there were not many entries for them. Seishounagon[7] wrote in her Makuranosoushi[8],

'Hoshi wa subaru. (Among stars, Subaru is most beautiful.)'

She also wrote, 'Haruwa akebono.(In Spring, dawn is the most precious time.)'

As Akebono, the Sumo champion, came from Hawaii, this name was thought to be a strong candidate. As the observatory was in Musashino area, the name of another Sumo champion, 'Musashmaru,' was also suggested. In the selection meeting, the combat was fought by 'Mirai[9]' and 'Subaru[10].' Each camp had its own words to say. Both 'Mirai' and 'Subaru' have only three syllables, so they are simple and good. If we look at only vowels, in the former 'i' repeats with 'a' in the middle, while in the latter 'u' repeats with 'a' in the middle. Those in the 'Mirai' camp says,

"I is intellectual and sharp but U is blur and dull."

Those in the 'Subaru' camp says,

"A word related with the sky is better."

It was reported that the final decision depended on the words of Director Kozai,

"We cannot expect the funding soon with the name 'Mirai' ."

'Subaru' is of course a Japanese name for the star cluster Pleiades. In China, it is 'Boushuku.'[11] We can recognize six or seven young blue stars in the cluster with naked eyes. The cluster has more than one hundred stars if we include faint members. They were born almost at the same time and their age is estimated to be about ten million years. It is in the constellation Taurus and is a conspicuous existence twinkling in the winter sky. A car company already used the name Subaru, and many people were aware of that. I belong to the generation that knows 'Subaru 360' well, a small car with small displacement engine in the early ages of car popularization. The car Subaru may be one of the first class cars now, but I did not like the idea that people might think that the telescope was donated by a car company. In the U.S., the segmented mirror telescope of the California Association for Research in Astronomy that was once called as 'TMT' was funded by a business family, was named as 'Keck' telescope, and its construction was on the way.

Pleiades = Makali'i = Subaru

I thought,

‘Well, it doesn’t matter. Subaru is originally a name of a star cluster. We astronomers have the right to use it. We only allowed a car company to use the name for its car.’

The word ‘suberu’ is a transitive verb that means ‘unify.’ Its intransitive verb is ‘subaru’ and its meaning is ‘get together.’ So, ‘Subaru’ is a star cluster.

When the nickname of the telescope ‘Subaru’ was reported to Hawaii, we were informed that in Hawaii the star cluster was called Makaliʻi and was used as a guide of navigators since the ancient time. Interestingly enough, its meaning in Hawaiian language is small eyes. First, our telescope was thought to be a ‘Big Eye’ but it ended up as ‘small eyes.’ This may represent the difference of scale felt by humans and scale in the universe. So, this episode is just right! Hawaiians who shipped across the Pacific Ocean, took the Pleiades that rises from the horizon as small eyes of gods that look at them from the sky. On the other hand, what we call a big telescope whose aperture is eight meters is a small tool in the universe. Only a tiny fraction of the light wave that travels several hundred million years through space gets into the surface of this mirror. Other photons that hit the Earth are not used at all. In so thinking, I was satisfied with the name ‘Subaru’ not representing a kind of flamboyancy seen in the Chinese character 「昴」 but as a modest prayer that we pray with the eight meter telescope which is ‘the small eyes’ of mankind.

The groundbreaking ceremony was held on the top of Mauna Kea on July 6, 1992. In Japan Standard Time, it was the day of ‘Tanabata’ festival. That day at the site, the wind was strong. We worried much about the weather, but the ceremony at the summit was blessed with clear sky. When the party got down to the city of Hilo in the afternoon, it started to rain and the rain got strong when the celebration party was held in the evening. In the National Astronomical Observatory in Mitaka, Tokyo, Subaru Project Office previously called as Project Office organized a party celebrating the groundbreaking in the patio.

The altitude of the summit of Mauna Kea is four thousand two hundred meters. The preparation of the ceremony to be held there needed enormous work. One hundred and fifty people were going to attend the ceremony. Transportation, safety problem, etc. Dr. Kyoji Nariai was on the Big Island since May as the Representative of the National Astronomical Observatory and was engaged in negotiations with the University of Hawaii and the local government. I knew that someone had to be sent to Hawaii for a long period and do this kind of work, but it was difficult to select a person because of the language problem and family matters. In such a situation, Dr. Nariai raised his hand voluntarily. He spoke several languages. I could not think of a better person than him. However, in Hawaii, nothing was ready to support him. As he accepted the job, all the other members had ease of mind, but he bore this burden devotedly. I presume that he felt as if exiled to an island. If no one accepted to go, the project of installing a telescope in Hawaii might have had collapsed.

His job was not restricted to preparation of the ceremony. Before the start of construction, we had to go through the environmental assessment. He made a contract with a local consulting firm to make evaluation of the effect on the flora, fauna, geology, etc, and to make survey of the remains of the ancient Hawaiians. It was reported that the site was a habitat of a rare kind of spider. You may think it unbelievable because the site is a rocky mountain like the surface of the Moon. A little below the summit, there was a place where the ancient Hawaiian got hard stones to make stone tools. In the Subaru Telescope Project, how much work would be done? How would it be operated? How much amount would be the cut and fill of soil? Where the extra soil would be put? How the drains would be made? Where the road is made? Etc., etc. When he finished these tasks, then he negotiated with the surveying company to make a precise map. In the summit area of the Mauna Kea, there are hills and valleys, but there is no significant landmarks. So, it was not easy to determine the sub-lease area without a precise map. The sub-lease area of about four acres and the position of the fixed point, that is the crossing point of the horizontal axis and the vertical axis of the telescope, were determined with the land survey coordinates of the Big Island based on the aerial photographs. The contour map needed one foot precision.

After such documentation work, he had to attend the local public hearing meeting. Among the local people, there were some who do not like that their sacred mountain is disturbed.

They may have thought,

‘The area of the Big Island around Mauna Loa is governed by the goddess of fire ‘Pele’ and the area around Mauna Kea is governed by the goddess of ice and snow ‘Poliahu.’ Astronomers, even foreign ones, came here and built strange building. The mountain ridge was beautiful, but now it has many knots. Many cars and people go up and down. The quietness of the old times is no more found.’

I wanted to respect their feeling. It is connected to the feeling of preserving the natural environment. Constructing the Subaru Telescope means in one sense doing something to the nature and changing the environment. But does it mean destruction? Subaru Telescope is a new technology telescope. Telescopes of old times were built in the natural environment and were operated by the mechanical governor and human eyes and human hands. Subaru Telescope is controlled by computers and its building is air-conditioned. Observed data are transferred from electronic camera to the computer for storage, then sent to the headquarter in town through optical fiber line. Still I wanted to think

‘A big telescope that peeks into the universe is a necessary tool for the Earth.’

Big sciences may be categorized into two; big sciences that are ‘soft to the earth’ and big sciences that are ‘hard’ to the earth. Sciences of accelerators and nuclear fusion aim at producing and governing a new environment that did not exist on the earth. Space science aims at going to the outer space above the atmosphere. Gene science aims at creating a new nature. All of them seemed to me ‘hard’ sciences. Astronomy and earth science are fundamentally passive sciences although its tool may become big or its instruments may be distributed in wide area on the earth. The last two add to our knowledge new information on the nature without changing it.

‘Am I right? Accelerator also aims at knowing the nature and build high-vacuum tunnel of several kilometer long and make accelerated high energy particles collide. Astronomy may have joined 'hard' sciences at some phase.'

I could not totally wipe out this feeling. I got a telephone call from Dr. Nariai,

"Public hearing went smoothly."

Preserving the environment is a big concern for the local community, but a bigger concern was on the economy.

'How much money is spent locally? How much is the construction cost? How many people will come to work after completion? How many people will be hired locally? How much will be the consumption of electricity?'

These were also natural responses.

On the day of groundbreaking, the president of the University of Hawaii, the Senators of the United States elected in Hawaii, and other local officials were present at the ceremony on the summit. In their congratulatory addresses were included their hopes for promotion of local economy besides the promotion of sciences and friendship between U.S. and Japan. From Japan, Mr. Hatoyama, the Minister of Education, attended with his wife. Local citizens of Japanese ancestral origin paid great care as it was the first visit of the Minister of Education from Japan. The Minister changed his schedule many times as he was a busy person. Dr. Nariai who stood between the Minister and the local people had a lot of trouble in adjusting the schedule. As it was anticipated that the Minister would stay overnight, an evening meeting was considered. But Hilo, Hawaii is a small town in U.S. No restaurant is open at eight p.m.

'Let's ask some restaurant to open until late so that we can have a welcome party.'

Local citizens of Japanese ancestral origin made many telephone calls and reached a successful plan. Then he received a message that the Minister's overnight stay was canceled.

The ceremony was made into two parts. The University of Hawaii was responsible for the ceremony for land that has a little bit of religious tint and the National

Astronomical Observatory was responsible for the groundbreaking ceremony. The ceremony for land was done in Hawaiian traditional style. The priest's costume and behavior reminded me of those of Shinto [12] . On the summit of Mauna Kea above the sea of cloud with his costume fluttering in the wind, he recited the Hawaiian prayer with similar modulation as Norito [13] and sprinkled water with brushwood of local tree instead of Sakaki [14] . I thought,

'Shinto must have come from the south.'

The groundbreaking ceremony was done in Hawaiian traditional style. About ten guests of honor poked a heap of soil with sticks of about two meters in their hands instead of hoes. Unconciously, I shouted at my top voice,

"Yoishoo, yoishoo, yoishoo..."

An American attendee asked me,

"What did it mean?"

He did not understand what the shout meant, but the shout was popular as it was energetic. According to the plan of ceremony, the Minister of Education, Mr. Hatoyama, was to speak in Japanese and I was going to read the English translation phrase by phrase. When I was going to give him the draft of his congratulatory speech, he took the English draft saying,

The groundbreaking Ceremony on Mauna Kea. Each participant holds own O'o stick, the traditional Hawaiian tool to dig soil. ©NAOJ

"I will do it in English."

As it was windy, I could not catch exactly what he said. While I was a little bit confused, he stood on a wooden box that was there as a podium with microphone in his hand. His instantaneous decision fitted the groundbreaking ceremony of Subaru Telescope and was well received by American attendees. Uta recorded his speech with her handy-recorder. She wanted to introduce the ceremony to European listeners of Radio Japan.

The Minister and his wife had to leave halfway through the celebration party to return to Honolulu. When the party was in full swing, Uta and I drove a car with the Minister and his wife in the back-seat to the airport. It was raining in torrents. I took the chance to ask him,

“Thank you very much for coming. I anticipate many things to be overcome from now on as this is the first undertaking in foreign land. I ask you to help this pilot project.”

His wife and Uta were talking about children and pottery. After sending them off, I was attacked by tired feeling. Even at normal time, I get tired after climbing up and down the mountain. These days, I was all right because I strained my mind although there were many meetings for the preparation of the ceremony. I even wanted to go back to my room in the hotel to have a little rest, but I had to go back to the party. I had pain in the stomach. I thought,

“It was good that Uta was with me.”

Professor Kaifu, as he is younger than I, was leading the party lively, but he confessed me later that he had toothache at that time.

Before we reached the groundbreaking ceremony, we had to do two tasks; legal procedures that were done by Dr. Nariai and execution of ‘Operating and Site Development Agreement (OSDA).’ The latter was mainly negotiated in the Institute for Astronomy, the University of Hawaii in Honolulu. Since the time around two years ago when the Fund for Survey of Installation was appropriated, opinions of Japanese researchers rapidly moved to conversion. That fifteen percent of the Subaru Telescope observation time is allocated to the University of Hawaii, that a representative from Hawaii attend committees so that opinions of University of Hawaii can be taken into the committee decisions, etc. These items were understood as matters of course but it was not so ten years ago when we started to discuss the draft. In these ten years, regents of the University of Hawaii and other members visited Japan, and many young researchers visited Hawaii and spent researcher's life and observed with the 2.2 meter telescope of the University of Hawaii at the summit. The University of Hawaii offered Japan ten percent of the observational time of this telescope. The big power of promoting the mutual understanding was the actual interchange of personnel rather than arguments over a table.

There were three big items to be solved before the final draft of OSDA; housings of construction workers, fund for joining the Mauna Kea Observatories, insurance and copyright. Dr. Karoji and I worked on these. In order to start construction at the summit that is 4,200 meter above the sea level, housings for construction worker must be made at Hale Pohaku that is 2,800 meter above the sea level. Hale Pohaku and its surrounding are within the nature reservation area and are habitats of rare floras and faunas. They are also in the hunting area. So very strict environmental assessment is applied. Very severe conditions were required by the local community when the mid-level facilities for international use was opened. Temporary housings that are common in the construction sites in the mountain area in Japan are not allowed. Even if Subaru Telescope is the sole user of the housings, they are to be used almost ten years.

It is not only Japan that does construction works at the summit. The Keck telescope that will be built in the neighboring site to ours already started construction. It uses housings that were already built at Hale Pohaku. Gemini Project that will start in the same year or one year later than ours plans construction works on Mauna Kea. The National Astronomical Observatory of the United States planned NGT (Next Generation Telescope) project that is a project to make 16 meter equivalent composite telescope. At the final phase, it changed into Gemini Project that constructs two 8 meter telescopes, one in Chile and another in Hawaii. The project is going to be an international cooperating project with U.S., U.K., Canada, and others. A person of Gemini in charge of construction suggested to construct housings with U.S. and Japan as cooperating members. U.S. side has already ordered the fundamental design. The negotiation was made with the University of Hawaii standing in between. But it did not go smoothly as it affects the interests of construction companies. Share of cost was unmanageable. American systems and Japanese systems treat this kind of things quite differently. In the mean time, their site manager was dismissed. One full year passed without any progress on this item. Finally, it was agreed with the University of Hawaii that companies on the Subaru Telescope side realize the housings.

One morning when I was alone in a hotel in Waikiki to settle this problem, I had strong pain in the abdominal domain. I recovered from it within one hour. But this was the first attack that repeated many times.

Hale Pohaku facitlities at the height of 2,800 m sea-level.

Share of the expenses is necessary to join the Mauna Kea observatories as its user. In order to make the Observatory as it is now, the State of Hawaii and the member observatories paid a lot of money to develop the infrastructure. Compared to the time I first visited the island for surveying purpose, roads are remarkably better, the mid-level facility is renewed, commercial electric line is constructed up to the summit, and the roads in the summit area are now paved. The computer network between the summit and the mid-level facility is complete and the observers can access their telescope at the summit from the mid-level facility. As a rule of the Mauna Kea observatories, the share of the expenses of new member observatory is deposited at a bank account and later used for the maintenance and development of the infrastructure. In the case of Subaru Telescope, the priority in the expenditure was agreed as the widening and maintenance of the road for the safe transportation of the eight-meter mirror and the extension of the electric and the communication lines to the construction site of Subaru Telescope.

In the Japanese system, it is possible to pay share of expenses spent on the construction of the Subaru Telescope within the same fiscal year. But it is difficult to pay ‘the share of expenses’ defined here from the Special Budgetary Account for the National Universities. And it is also difficult to assess the amount. The University of Hawaii made in 1983 the Mauna Kea Science Reserve Conservation and Development Plan and assessed the amount of the share of expenses for a new member of Subaru Telescope class. The amount was written in U.S. dollars in 1983 rate and is changed according to the consumer price index in Honolulu.

‘The rate of yen versus dollar changes. The system of payment is different between U.S. and Japan. The fiscal years are not the same. It is necessary to thrash out a solution to the problem, otherwise unpredictable troubles may occur.’

It was not only us who worried about this. The University of Hawaii also was thinking the same. So, it was agreed that the OSDA has a statement on the amount that is assessed with an assumption that the construction starts in July, 1992. When the payment is delayed, the amount is changed according to the price index. In view of the problems we have met because of the difference of the laws and rules between the two countries, it was agreed,

‘The final draft will be written half year before that means by the end of 1991, and it should be read by the officers of the two countries.’

The amount of the share of expenses was determined by that time, but the insurance and copyright were not. After the new year in January, Dr. Karoji and I worked on these. In Japan, national organizations usually do not purchase insurance. In case it is sued, the country is the one that meets the case. In Hawaii, it is quite ordinary to purchase insurance. The State of Hawaii does not think a Japanese observatory to be a governmental agency. So it asks that the observatory purchases insurance in order to avoid risk. In the draft, it was written,

‘The National Astronomical Observatory purchases insurance.’

Finally, it was agreed with,

'The National Astronomical Observatory arranges that insurance is purchased.'

Copyright and press release were discussed in February as the Japanese laws and rules were incomplete. On the last day, we had to make long telephone calls from the conference room of the University of Hawaii to the administrative division of the observatory in Tokyo and to the section in charge in the Ministry of Education. Because of lack of time, we had to end up with a compromise. The consumer price index announced a few days after that declined rapidly. Later, we were asked if the amount was right. We did not have any guilty conscience at all.

---

[3]Galaxy in Japanese.

[4]Ancient Japanese word.

[5]A word to be put in front of Yamato in the ancient Japanese

[6]Picture showing the status Budda attained.

[7]Female essayist in the eleventh century.

[8]Her book of essays

[9]future

[10]Japanese constellation name. Pleiades.

[11]昴宿.

[12]Japanese religion

[13]prayer of Shinto

[14]brushwood used by Shinto

5.4

Thus started the construction of Subaru Telescope. However, it was necessary to file the budget request every year to get money of the next fiscal year. According to the actual budget system of the Ministry of Education, the longest possible budget plan lasted only three fiscal years. So, it was necessary to break up the items such as the telescope or the building that needed long period for construction into many items with shorter periods starting year by year. It was not guaranteed that all the items in the budget request for the corresponding fiscal year would be appropriated. It depended on the economical situation of the year. Of course, we submitted the budget plan for the entire project to begin with, but it was only a target. After two years from the start, the eight-year project was already modified as the nine-year project.

The economy of Japan heated in the 1980s to cause 'Jiage'[15] phenomenon depressed rapidly in the 90s as the 'bubble' collapsed. It went to the bottom-low while we stood in utter amazement. As if giving an additional blow to the economy, Japan was asked to liberalize trade and Japanese enterprises were oppressed. They started to move the factories to foreign countries where cheap salaries were available, and it seemed that the hollowing out of the domestic industry would occur. If this had happened two or three years earlier, I am not sure if the large telescope project got the construction fund. I could not think that the bubble economy was irrelevant at all to the fact that Japan appropriated a fund of forty billion yen to astronomy. In the 1970s and 80s, Japanese big sciences were in blooms probably because the economy of Japan was on the upswing. As everybody is anxious about the economy in Japan now, it may be possible to complete Subaru Telescope, but we cannot be optimistic about the future of the academic culture of Japan that began to bloom.

'Well, the Japanese society is changing gradually. I hope it will become a country that respects academic culture,'

I repeated trips to Hawaii with such an optimistic view.

The royal wedding ceremony of the Crown Prince was followed by the Tokyo Summit with the President Clinton of the United States. Then, Miyazawa cabinet resigned and Hosokawa cabinet of the New Political Party of Japan started. The New Political Party of Japan tried to dig up new talented persons so that citizens might expect it to bring a new society. That activity affected Uta. I am not sure how serious the Party was, but Uta went to see the leaders of the Party as they invited her. It was clear that a negative result would come out. It was impossible for Uta without Japanese nationality to become a candidate of the Diet member.

"Eh! Don't you have the Japanese nationality?"

said the leader of the Party surprisingly. Uta is a wife of a Japanese professor. She has lived in Japan for almost thirty years. She has taught at the Tokyo Institute of Technology for fifteen years. She is the mother of three daughters with Japanese nationality. She is in charge of a program in German at Radio Japan of NHK. And she has paid the income tax and the resident's tax.

It was only recently that Uta applied for the right of permanent residence and was admitted for it. But she has to pay several thousand yen for re-entering permit every time she goes to Germany. She has to do alien registration. In short, she is a 'Gaijin.' [16] She took the chance to appeal the leaders of the Party the necessity for improvement.

'Nationality and 'Citizenship' should be treated separately. A citizen who supports the society should have fundamental responsibilities and rights. Gaijin has responsibilities but not rights.'

'So you think,'

was the responce of the inviters. For them, they could introduce something new if they assign a person born abroad, but not more than that.

Nevertheless, Uta and I felt that the postwar period was over and a 'New Age' would open up. Even the collapse of the bubble economy seemed to us as the labor pain of the 'New Age.' We reminded us of having had similar conversation when the Prime Minister Kakuei Tanaka appeared,

'A wild leader appears when the society needs changes.'

In the Unified Germany, the postwar got to an end and a new era of sufferings began. Economic reconstruction of old East Germany was a heavy burden and the economy of Germany stalled. A new group called 'Neo-Nazism' gained power and a murder case of a Turk occurred. Although the group was small, Uta heard the news with a nauseating feeling as if she was looking at a malignant tumor in her own body.

In the past, Turk laborers were welcomed because they filled up work force, but they are now hated because the unemployment rate is high. Not like a Gaijin in

Japan, a Gaijin in Germany is guaranteed of their rights as a citizen. That made the situation worse when he became a target of hatred. And Germany decided to send its army to Bosnia to support the UN force.

Although the destination of this big current of the time was not known, the large telescope project went on. Professor Kaifu who took the steering of the Subaru Project Office, completely grasped the project and showed his leadership which was his own nature.

In the first fiscal year of the project, creation of the division ‘Optical and Infrared Measurement’ was appropriated as the first step of personnels, and in the second year, in 1992, another division with a long name ‘Promotion of the Large Optical and Infrared Telescope Project’ was created and I became the division head. Just before the start of this division, Professor Yamashita who worked hard for the promotion of the telescope project retired, and Dr. Wataru Tanaka moved from the Department of Astronomy of the University of Tokyo. He joined the group of Dr. Iye, Dr. Ando, and Dr. Karoji who were doing the engineering side of the project. I knew Dr. Tanaka since the balloon-borne telescope experiment. He knew optics and control engineering. As the number of division increased, the number of competent young people increased. This made the project room more active. I wanted them to know various sides of this project and the big uncertainty arising from ‘constructing abroad.’ But it was difficult to inform them as these matters were thought by them as matters of the past. Every staff had his own dream and joined the promotion of the big project that was already running.

A little before the ground-breaking ceremony atop the Mauna Kea, I planned ‘Symposium for Internationalization.’ It was held in the auditorium of the Science Council of Japan. It was one of the activities with the Fund for Research from the Toyota Foundation. I aimed at giving clear informations on the background and problems of the large telescope project, but things did not go as I wished. Already at the planning phase, arguments went round and round without producing any fruitful result, and the number of participants were not so many as I hoped. The catch phrase

‘Science is very International’ raised an objection. This might have been too ordinary. ‘International,’ a word used everywhere used with ‘Science’ might have been too ridiculous. But I wanted to say,

‘The Large Telescope Project aims at the exploration of the universe. It is not only for Japan or only for Hawaii. It is our humankind’s dream. Subaru Telescope is an ‘Eye of Humankind.’ Fundamental sciences have this characteristics by nature. Big sciences are specially so.’

Sciences in Japan started as ‘science and engineering’ imported from the Western world, then grew in the mood of ‘catch them up, pass them,’ to win in the international competition. It was the ‘Nyoibou[17]’ of ‘strong soldiers, strong country,’ and it was supported by the ‘closed competition.’ Fundamental science as an academic culture never comes into bloom if it is not based on the spirit of ‘open competition.’ If the spirit is not strong enough, we cannot expect to prepare organization and systems to support it. In the actual international cooperative research, researchers do the excessive overhead work. Regulations of the laws of the national accounting system are very strict. They are sometimes interpreted to make the application smooth, but we cannot expect it everytime. Also it depends on the officer in charge. An item OK’ed by a previous officer in charge can be denied by the next officer in charge. Researchers standing between foreign countries and the Ministry of Education have to read and prepare almost all the documents in English. For more than one hundred years since the start of the Meiji Era, Japanese system used a motto ‘Wakon Yosai.’[18] It is still alive as far as the international way of thinking is concerned.

Subaru Telescope Project is moving. It will see through the edge of the universe with a large telescope built in a foreign land, Hawaii. The project is moving because there is no law in Japan to forbid it. But we do not have laws to support it either.

‘How will a national property of several tens of billion yen value be maintained and operated? Is it possible to create a ‘station’ of the National Astronomical Observatory in Hawaii? Employees of the National Astronomical Observatory who work there every day, can their workplace be Hawaii? How will be allowances working abroad?'

There were no laws to decide the answers to these problems.

Participants of the 'Symposium for Internationalization' from many fields of science had their own attitudes. Only one common thing shared by all was the desire,

'Isn't it possible to change the actual laws and regulations binding the activities of the international cooperative researches? They are too much.'

As Japan uses single fiscal year system, a researcher on a trip abroad must be back to Japan on the last day of March. The date doesn't mean essentially anything for the research activity. It corresponds to one point on the revolution orbit of the Earth. The researcher who comes back to Japan on the 31st of March wishes to go back on the 1st of April. But if he goes abroad with an official passport, it takes many days to get a new passport after application. Work is going on while nobody from Japan is at the site.

After I came back from the ground-breaking ceremony atop Mauna Kea, Mrs. Masuyama and I worked together to make up the proceedings of this symposium which, I think, was unsuccessful. Later, many organizations asked us for a copy of this proceedings.

'When using money of the government, we cannot expect flexibility. As we are going to make international activities, we need money that we can use with flexibility.'

I began promoting seriously creation of a foundation that I was thinking for some time. A foundation cannot be owned by an individual. It should not be totally independent of the observatory because its main aim is to support activities of the observatory. But sticking only to the observatory seemed to me very short-sighted. It was not my intention. After some inquiries to the Ministry of Education and Tokyo-City, I found that an 'academic grant foundation' controlled by the Ministry of Education can be created with an endowment of two hundred million yen. Two hundred million yen with an interest rate of five percent yields ten million yen of interest that can be used for activities. That amount may be the minimum. Can I expect double that amount? But as the bubble collapsed, two hundred million yen is an enormous amount and that I was at a loss how to collect it. Donation at the time of creating the foundation is not exempted from the tax. Therefore, for donating companies, it meant to throw away the profit.

For me, it was essential to create a foundation. I meant to use it for public relations and popularization of astronomy. Service activities to the society may be limited if a government entity, National Astronomical Observatory, is going to do by itself. I also thought that if the station in Hawaii needs a corporative status other than that of the country of Japan, the foundation can offer such status although it may be provisional.

I consulted first with the director of the administrative division about the plan of creating the foundation, then spread the idea to a wide range.

"It's a business method of a samurai.[19] I cannot agree with you!"

When I said "I wish to collect two hundred million yen", most researchers denied on hearing it.

It was impossible to have their help in collecting the endowment.

"I ask you to help us,"

I visited presidents, counselors, and directors of companies whom I had acquainted with one by one. The timing was certainly not good. All the companies were in the business depression and were trying to improve their business. So, they had many reasons to refuse cooperation. Nevertheless, I visited companies patiently. Then, some people began to ask me,

"Whom else are you talking to?"

which, I thought, was a sign of softening. Japanese style of honor, 'in a row,' may be the point. I dared to visit Mr. Nihachiro Katayama, the president of the Mitsubishi Electric Corporation, who was touched by the astronomical adventures at the summit of Mauna Kea and asked him to be the representative of proposers of the foundation.

After he accepted to be the representative of proposers, it was relatively smooth to get donating companies on a condition that each donar donates the same amount.

At the end of March, 1994, the 'Foundation' started. Professor Kozai accepted to become the chairman of the board of directors on the condition that I continue to do the business practice. By that time, the business recession after the collapse of bubble was in a serious state, and Japan adopted low-interest policy, and the official bank rate was coming close to the lowest possible line. For the activities of the foundation, I had to ask additional donations because the interest of the endowment was not sufficient enough. So, I had to continue visiting companies. In the first phase, the foundation increased my work rather than it helped me. Anyway, the operation of 'Promotion of Astronomy Foundation' started. The next task was providing the environment for engineering development in the observatory.

---

[15] buying up small plots of land for consolidation and resale

[16] foreigner

[17] Magic stick (如意棒) of the super-monkey Son-Gokuu (孫悟空) who followed Monk Sanzou (三蔵法師) from China to India.

[18] 和魂洋才:Japanese spirit combined with Western learning

[19] Japanese warrior

5.5

Reinforcement of soil at the summit of Mauna Kea started. In the mean time, the place which used to be a ridge became flat. Then, a large hole was excavated. Artificial ground of many layers of soil-concrete was rolled out. The altitude is 4,200 meter high. All the workers were big, but they were breathing hard. Judging ability may be lowered because of low atmospheric pressure. A worker was killed by an accident when his tractor turned over because of his simple mistake in judgement.

As the work proceeded, the time of importing steel frames for the basement of the building from Canada to Hawaii came close. This was import of materials. Generally, they were to be taxed. However, as we were going to import not only the basement of building but also the upper part of the building and the telescope itself, it was an important problem whether the import is made duty-free or not.

A large hole was excavated. ©NAOJ

The bottom part of the concrete pier is made. ©NAOJ

Concrete pier is now half-way. ©NAOJ

Concrete pier is finished. Workers are now preparing the base of the observation building. ©NAOJ

We had already a report of survey on the foreign observatories in Hawaii made by Dr. Nariai and Dr. Ando. As soon as the construction at the site began, Dr. Nariai stayed in a temporary office in Hilo and continued work of negotiation and survey while overseeing the construction at the summit. Observatories of various countries, who were usually cooperative, did not teach us where they kept the documents of duty-free procedures. The University of Hawaii was not positively cooperative to this survey, and answered on our frequent request for the procedure;

'This kind of matter depends on the bi-lateral agreement of the relevant countries. Final decision will be made by the negotiation between Japan and U.S. You can learn however something from examples of other countries.'

So, the negotiation had to be done through the Ministry of Foreign Affairs with the Department of State. Our case may meet the special duty-free item described in the law of customs, but the final decision was in the hands of the State Department.

'Who in Japan does judge when to file the application? Does the result depend on the filing agency?'

We were facing a delicate problem. I met the officer in charge of the Ministry of Foreign Affairs every year to report the progress of construction. But he may not take action in such a definite problem unless an officer in charge of the Ministry of Education asks him officially. Ordinarily thinking, importation duty-free is not limited to this case of the Ministry of Education. Other ministries may handle many such cases commonly. So, I guessed that the Ministry of Foreign Affairs handle such cases mechanically. As the time limit was close, I asked the Ministry of Education to handle the case, then everything went smoothly although it took time. Some time later, we received an answer from the State Department through the Ministry of Foreign Affairs that if a container is put a label of 'JNLT' it passes the custom duty-free. Following advice from other foreign observatories, we reported this to the custom officers in Honolulu. So, everything went smoothly when the actual customs clearances were done.

Another more difficult problem was the Use Tax of the State of Hawaii that is a kind of import tax between states. In the United States of America, if a company carries material from other states for its enterprise, it has to pay tax. Telescope was duty-free because it was owned by the Japanese Government and is not for sale. In the Revised Hawaiian Statutes, there was no provision for such a case. We expected that the materials for telescope are exempted from the Use Tax because they are carried into the State for the use of an enterprise of public benefits. For Japan, it surely is an enterprise of public benefits, but we were not sure if the State of Hawaii approves it. Hawaii archipelago does not have any particular natural resource or industry. For Hawaii, the Use Tax from materials imported from Japan cannot be an amount to be disregarded. The University of Hawaii standing between the State and the Observatory could only say,

"We do not know any case of observatories existing atop Mauna Kea taxed when they were constructed."

The Subaru Project Office of the National Astronomical Observatories made a contract with an attorney in a law firm in Honolulu and made him negotiate with the authorities of the State taxation. The attorney began a bothersome study,

"Are these materials owned by the Government of Japan?"

“Aren’t they carried into the State by a company who contracted with the National Astronomical Observatory which is an agent of Japanese Government?”

Logical arguments of interpretation of laws followed. We translated the English documents into Japanese, and vice versa. We consulted with the legal division of companies and the Ministry of Education. The Use Tax matters were more delicate than the custom’s duty. After exchange of a pile of documents, we ended up with a solution,

“The Observatory receives the materials before they pass the State boundary and supplies them to the company for construction works.”

This solution, however, required a lot of office work in the Observatory. Dr. Karoji, the manager of the project room, and I were in charge of negotiations with outside of the Observatory. Dr. Karoji had a marvelous talent to do this kind of work. He always kept cool. His colleagues were anxious because he seemed not to care about work whose deadline was close, but he always made it in time.

Our visits to Hawaii got more frequent than before. As the project was on the way, my force of will was strong, but my physical strength showed signs of waning. The acute pain of stomach that I experienced in Hawaii a little before came more frequently, and dull pain in the stomach stayed always with me. In the meantime, I learned how to handle these pains. When I noticed the acute pain coming, I sat on a chair or a bed and threw the upper half of the body forward folding my body. I stayed with all my strength holding my knees. This may have looked like a shrimp. After half an hour, the pain just went away. The dull pain was more difficult to deal with. The only solution was to eat and drink less. As I had to meet many people, this was not achieved easily. Probably because of these pains, my face skins became flabby and I could easily pinch a part of it with my fingers. Part of its cause was my age. I was doing my best in writing papers until the budget was appropriated, but I was doing slow these days as the actual work of the project kept me busy. Before the start of the project, I put me a burden of writing three papers per year, but I was writing one paper per year. It became difficult for me to continue to study galaxies in massive scales. So I joined the group of test observations of an instrument aimed for use with the Subaru Telescope, obtained near-infrared data of galaxies, and tried to analyze them with young researchers.

Andromeda galaxy and our Milky Way Galaxy, are big group of hundreds billions of stars. As the pictures of the Milky Way and the Andromeda galaxy show, there are dark nebulae. Dark nebulae extend to wide area where we cannot clearly distinguish them and absorb or scatter stellar lights. In the infrared, absorption and scattering are weak, so we can see the entire body through dark nebulae. I got anxious to know the effect of dark nebulae in my previous study of galaxy in the optical light. So, I took images in the infrared and compared them with my previous data in the optical light to evaluate the effect of absorption. Our solar system is located close to the central plane of the lenticular shaped Milky Way galaxy and is looking up the universe. When we look at the central region of the lens surface, there is a band of dark nebulae in the constellation Sagittarius and we cannot see through the center of our Milky Way galaxy. But in the direction vertical to the Milky Way, that means perpendicular to the lens surface, it is transparent as if there is no absorbing material.

'How is the absorbing material distributed in our Galaxy? How thick is it? How is it in the Andromeda and other galaxies?'

This was the awareness of the issue I had.

This problem is deeply connected with the world of galaxies near the edge of the universe that we are going to see with the Subaru Telescope. Stars are born from interstellar clouds that float among the stars, and a part of them return to the interstellar clouds after their lives terminate. In the interstellar clouds, dust particles are created. And they cause absorption. Cores of dust grains are made of the atoms of metal, carbon, and silicon that easily solidify. Cores grow as they are covered by shell of ice. Interstellar dust that causes absorption is richer if the total material of the interstellar cloud is larger. As a galaxy gets old, cloud is used up and only stars are left, the dust quantity gets small. At the initial phase of the universe when the primitive galaxies were born, most part of the galactic mass must have been in the cloud. According to the theory that only Hydrogen and Helium were produced by the

Big Bang, dust will not be made. Dust grains start to hang in the space only after the first generation stars were born and the natural nuclear reactor worked to produce heavy atoms that were to be spread around. If this is the case, in the history of the universe when the clouds were still bountiful and heavy elements increased to a certain level, there must have been an era when a large quantity of dust grains prospered.

'When did it happen? Was it ten billion years ago? Or fourteen billion years ago? Were the galaxies of that time covered with dark nebulae?'

If this is true, although the Subaru Telescope is a powerful telescope, it cannot detect such galaxies in the visible and infrared light. Light emanating from stars and galactic nuclei is absorbed by dark nebulae and is re-emitted in the far-infrared region as thermal radiation from heated dust grains. This must have happened when the expansion velocity was large. So, we receive the radiation with large red-shift. It may be only in the milli-meter or sub-milli meter radio region.

I worked on this theme with a foreign research associate from Vilnius Observatory of Lithuania, Dr. Vladas Vancevicius. Vladas was a young researcher of age 35. He had experiences of observing with the six meter telescope of the former USSR. But after the collapse of USSR, he could not continue research at all. According to the request of a senior astronomer from Lithuania whom I met at the General Assembly of the International Astronomical Union, I arranged to invite him to Japan for one year as a special foreign research associate of the Japan Society of Promotion of Sciences (JSPS).

"Nothing changed at the Vilnius Observatory. Salary and research fund are the same as ten years ago. Only the prices went up by a factor of several times of ten. It doesn't help our family budget if I get the salary or not. Researches with pen and paper is O.K."

Such was his black joke. Big and healthy Vladas learned the way of living in Japan quickly. He rented an apartment house close to the Observatory, and he cooked himself. JSPS controlled by the Ministry of Education is a special organization. It treated our foreign researcher very kindly and with big flexibility. When he visited its office upon arrival, it paid the salary and house-rent in advance, and refunded the travel cost immediately. It paid the premium of the travel insurance, and the expenses for study of Japanese language. Compared to the invitation program of foreign researchers by the Ministry of Education, this program is far more humane and well arranged for international exchange. The treatment I received in Germany thirty years ago as a national scholarship student and this program are at the same level.

Dr. Vladas Vancevicius, Dr. Nobuo Arimoto of the University of Tokyo, and I made a team and studied 'dusty galaxies.' Galaxies were dusty in old times. It became clear that in counting galaxies in order to know the structure of the universe, we have to take into account of the evolution of the brightness of galaxies due to age and also the evolution of dust.

'Can I see the edge of the universe with Subaru Telescope?'

I worried a little bit.

COBE satellite launched by NASA succeeded in accurate measurement of the cosmic 'background radiation.' The team of University of California at Berkeley found with their cooled short-millimeter radio telescope on board of a satellite that the cosmic background radiation is the blackbody radiation of the absolute temperature 2.7 degrees and its homogeneity as to the direction is very high. Their data had very high accuracy and brought to light the 'remaining' radiation of the Big Bang that was inferred from ground-based observations since 1960s. The fluctuation of its intensity on the sky was said to be less than one hundred thousandth. A new riddle appeared. How did large scale structures of the universe such as superclusters of galaxies and supervoids from such highly homogeneous initial universe? As if following this result, the team of Fermi Laboratory in Chicago announced the detection of top quark in an experiment with a huge accelerator. This elementary particle had been long sought after as one of the most fundamental elementary particles that make up material.

These elementary particles are thought to have made the framework of the material world interacting each other during the Big Bang and in the early universe.

'What particles were born just after the Big Bang? How the first generation celestial bodies were formed from what kind of fluctuation? Were they quasars, or primitive dusty galaxies, or unknown celestial bodies?'

I wanted to know the fact. Later on, this study of absorbing matter developed into 'the Study of Dark Nebulae in the Andromeda Galaxy' that I worked with Dr. Motohide Tamura, a young excellent astronomer of the National Astronomical Observatory.

While I was busy with the study of 'observational cosmology' and the issue of import of Subaru Telescope material, the time of election of the director of the observatory approached. Since 1988, the start of the National Astronomical Observatory, Professor Yoshihide Kozai was the first director succeeding the directorship of the Tokyo Astronomical Observatory. The term of the director of the National Astronomical Observatory is four years. There was an agreement that if re-elected, he can stay at that post with two years as a unit with a condition that his age is below sixty three at the start. Professor Kozai was re-elected at the 1992 election, and there was a possibility that he is re-elected again.

Andromeda galaxy (= M31).
©Kiso Observatory (Institute of Astronomy, School of Science, The University of Tokyo)

I thought what would happen when elected as the director. Four years from the age of fifty seven means sixty one years of age. This guarantees one year longer than an ordinary professor. The last year would be the year of the beginning of test observation for adjustment after installation of Subaru Telescope was completed. If I retire at the age of sixty, the telescope is still being installed. Young people are now enthusiastically promoting the project. What is needed in the future is setting up the framework of 'installation of governmental organization in foreign land.' In order to do it, negotiations at higher level is indispensable. Thinking this way, it seemed to me that to work as the director was meaningful. But the director is an administrator who is responsible to the entire observatory. He has to meet staff, adjust the budget request, and attend many kinds of meetings. Professor Kozai did these works well. I am not so good at these kind of duties. I prefer research to administration. I do not suit for an administrator. What I wanted was to devote myself to the promotion of the project and research while in the observatory, and after my retirement, become a professor of the University of Hawaii and use the Subaru Telescope. I could not do my research thoroughly because of my promotion of the project, but I thought I reserved power for research. If I work as the director for four years, the relation between Subaru Telescope becomes indirect, and I probably lose the sense of research. I thought there would be someone who fitted more than I.

'Professor Kozai can continue, or Professor Kaifu can do it.'

If Professor Kaifu gets the directorship, I thought someone in the project team can take over his role. In and around the observatory, many people thought that way and narrowed the candidate. But the board of regents who has the power of decision making judged differently.

That day when I was taking lunch with the staff, the chairman of the board of regents called me on the phone.

"You were elected as the candidate for the next director. Will you accept it?"

"Yes, I will accept it."

I had already made it in my mind to 'accept and do my best' if the judgement at the level of the board of regents wanted it. But it took several months before I was fully for it.

“I will devote myself to the setting the framework with the broad view rather than the direct work on Subaru Telesope. As I accepted the next directorship, I will do my best as the director. Farewell to research for some time.”

When I reached home, I said to Uta,

“I was elected as the director.”

She said frankly,

“So, you can make it.”

In the past, we joked each other,

“What would you do if the University of Hawaii does not hire you although you wish to be a professor there,”

“We will start a ramen [20] shop in Hilo expecting observatory staff as clients.”

Now it was not time for joke and we felt somehow gloomy.

---

[20] Chinese style noodle

[Published] **Keiichi Kodaira/Kyoji Nariai**: **2016**, NAOJ-Books : Makali‘i in Hawai‘i.

Chapter 6

Astro Heart

6.1

Uta and I decided to make a trip to see the ice floe before my term as the director starts.

The ice floe stayed thirty kilometers out from the shoreline when we decided the itinerary of our trip. It still stayed there when we arrived Abashiri city. The next morning, it came right to the shore. North wind brought it. Uta and I were staying at a hotel by the side of Lake Saroma. That morning, we got up early and rented skis, parkas, and shoes. We walked on the sandbank that stretched long between the sea and the lake. The sandbank was covered by deep snow. Only our ski-trails were left behind us. The completely frozen lake Saroma was on our left and the Okhotsk sea filled with the ice floe was on our right. Our breath was white. A big eagle was leisurely flying in the blue sky. Mountains of Shiretoko Peninsula were seen afar floating as if in a mirage. Water in the river of the continent became ice, floated through the Okhotsk sea, came here, and piled up as ice having a bluish tinge. This was a calm world without noise. We felt the north breeze comfortable as we sweat a little bit while doing cross-country skiing.

‘My health seems all right. Well, there is no other way than doing my best.’

Each of us was thinking of what would come during my coming directorship. As the ice floe reached the shore when it was blown by the Okhotsk north wind, we thought that we were driven away by some unknown force.

On returning to Tokyo, I started to sort out what I had in the observatory so that I could prepare the work as the director well. The amount of documents that I gathered as the head of the telescope project was enormous, but most of them had already been transferred to the Subaru Project Office. As to the remaining documents, I decided to keep only those I needed at hand and to throw away the rest. I decided also to part with the monographs and textbooks that I might not read again.

As the director of the observatory, I needed a secretary. The administrative division works for me, but as a slovenly guy, I needed someone who helps me. My predecessor Professor Kozai was a competent person in administrative work too, and did everything precisely by himself. As far as I knew, there had been no secretary in the director’s office. Mrs. Tei Masuyama who had worked for me for ten years was younger than I and did her work promptly. I wanted her to become the secretary in the director’s office. At the same time, she was a person needed by the Subaru Project Office as she knew all the history of the project.

‘I will ask her to become the secretary to the director’s office helping the work of the Subaru Project Office at the same time for the time being.’

I asked her to take the post. She did not give me a good answer at first, but finally agreed to accept the post.

After I moved to the director’s office in April, I remodeled the office. I rearranged furnitures so that the room have a bright atmosphere. I kept the door open so that everyone can come in at ease. I put my desk in front of the door, so a person entering the office could see me immediately. I wanted to show my attitude that the director is an administrative officer to whom everyone can speak to when needed. The secretary's desk was put by the side of the entrance. A small conference table was moved to the inner part of the office. I planned to use it as a space where I can spread out research documents when there is no meeting. In the corner diagonally across from the entrance was placed drawing-room set. This part faced the green courtyard. In Spring, we could see an early weeping cherry. Furnitures taller than desks were put only by the side of the wall. Several picture frames were hanged on the wall.

This style was received well by the staff of the observatory. As the office was easy to enter for everyone, many people including unexpected visitors dropped in and gave their opinion to me. I hung several pictures on the wall. Some said,

"It is good that bright pictures can be seen from the hallway."

The small conference table in the inner part of the office was used sometimes for research and also for lunch. Soon, it became the regular place for 'Mini-Seminar in the director's office' that was held at lunchtime. This was a thirty-minutes seminar with five or six members. Young researchers of various divisions in the observatory attended. The seminar held a specific theme and fixed members for about a year, then different theme and members were chosen. It was held only when all the members could attend. All the members including me gave presentation in turn. For a director, it was profitable to have a chance to discuss things with young researchers. It was my pleasure. At the same time, it worked to make communication among laboratories better.

At the same time that the new director began his job, 'Development and Experiment Center of Astronomical Instruments' started. Dr. Yukiyasu Kobayashi who accepted to take the responsible post of the head of the center went for a trip abroad with Professor Kaifu to see facilities of observatories in other countries. A new building with a dome was built in the campus, so we got a new place to develop instruments. The number of staff was still not many, but graduate students and research associates were gathering together. There was an atmosphere that 'a new thing starts.'

In Hawaii where Dr. Nariai and Mr. Nakagiri who raised their hands for stationing in Hawaii, the basement of the building was completed at the summit of Mauna Kea. The Board of Audit scheduled to send a group of staff to audit the construction work at the summit. Audit is usually an unwelcome ceremony, but in this case I was glad that the audit was scheduled. That the summit work is audited means that the Japanese government admitted the building to be a national property. They found several inadequate things, but nothing was mentioned about the fact that it was 'located in foreign land.' The base part of the summit building does not move, so it is classified as a 'building.' The upper rotating structure is classified as an 'instrument.' Its structural design is made by a company in London, structural steel is made in Vancouver, and a subcontractor in Hawaii builds it at the site. So, the team of companies for the summit work shifted to a new one. The project team of the Mitsubishi Electric Corporation, the main contractor, increased gradually young competent people. The meeting with the observatory created various sub-meeting. As fabrication of parts of the telescope and design of its control system were done at the same time, meeting was held quite frequently. So it was almost an endurance contest for members of the both parties. I think that our people of the observatory did well. However, main members of Mitsubishi team were tougher. I thought,

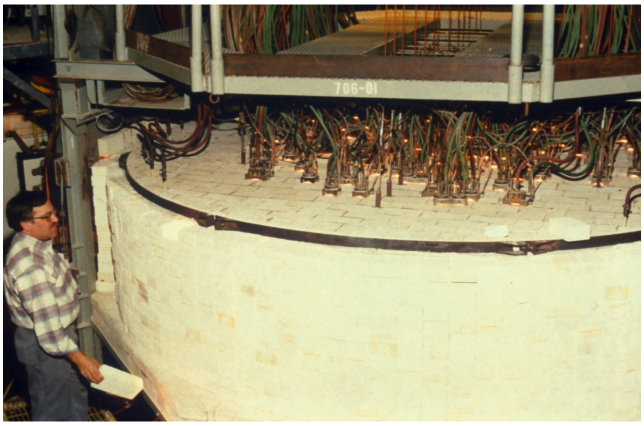
'If I were working like they do, I surely would get ill.'

6.2

The first task related to Subaru Telescope as the director of NAOJ was to attend the ceremony of shipping of the eight-meter blank as the representative of the Japanese owner. It was the ceremony to send out the cast blank from the glass company to the polishing company. Staff of the Subaru Project Office arranged that I, as the director of NAOJ, can attend the ceremony. I thanked their good-will and headed with Uta to

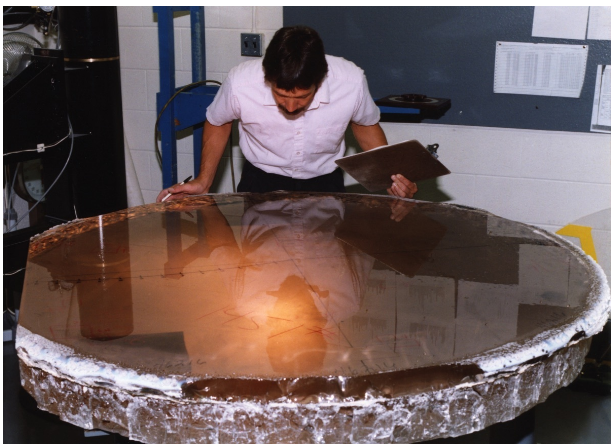
Canton, New York. Uta was equipped with a recorder and many cassette tapes so that she can use them during her broadcasting time of Radio Japan.

It was three years since the ceremony of contract. Looking for meeting with the completed mirror blank, my heart was too full for words. The mirror is the most essential part in the telescope making. It is the heart of the telescope. Corning Glass Works and MELCO checked the completed blank in detail and their data were already delivered to the Subaru Project Office. Half a year ago, 1.5 meter hexes were ready, and many calculations of simulation were done as to the best arrangement of hexes which gives the smallest thermal deformation that is caused by the residual small differences of CTE of individual hexes. By the control of robot arms, this deformation can be made null to make the mirror surface ideal. The completion of the thin meniscus mirror blank was only the first step of telescope making, however, it was one clear step forward. We had worked very hard at the initial phase of planning, and had a lot of hard times in getting a company to produce it.

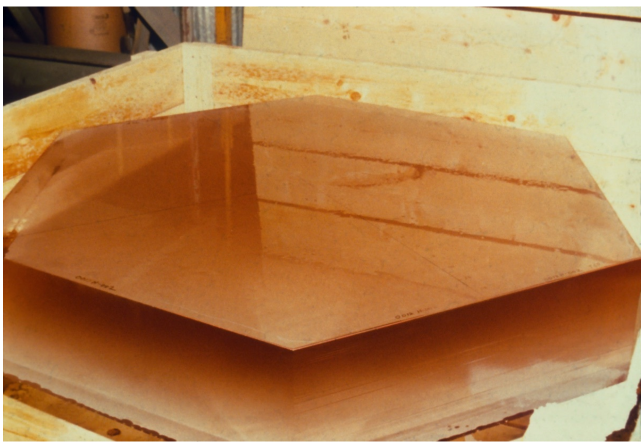


Boule is made in furnace.

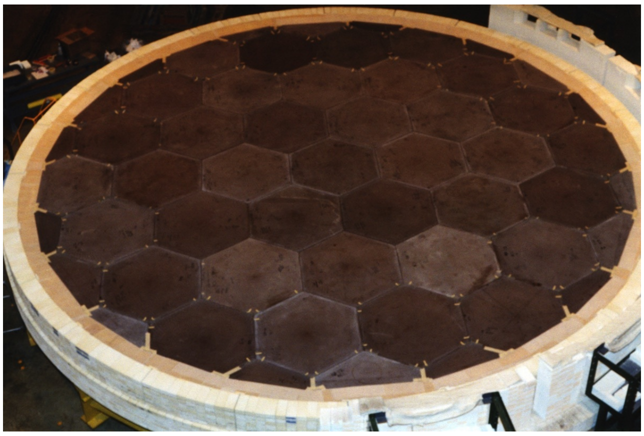
Boules are stacked.



Stack is cut into two, and one side is polished.

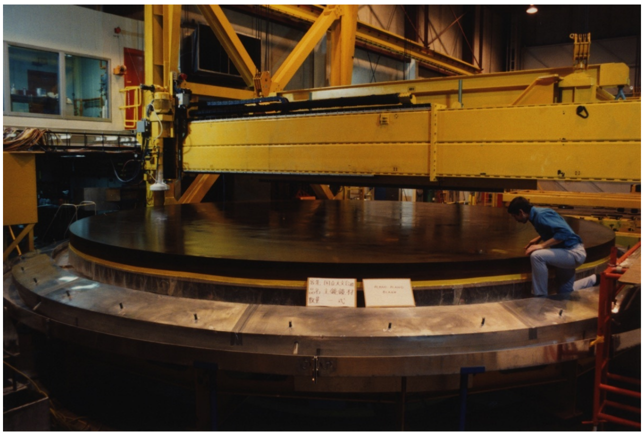


Then is made into Hex.

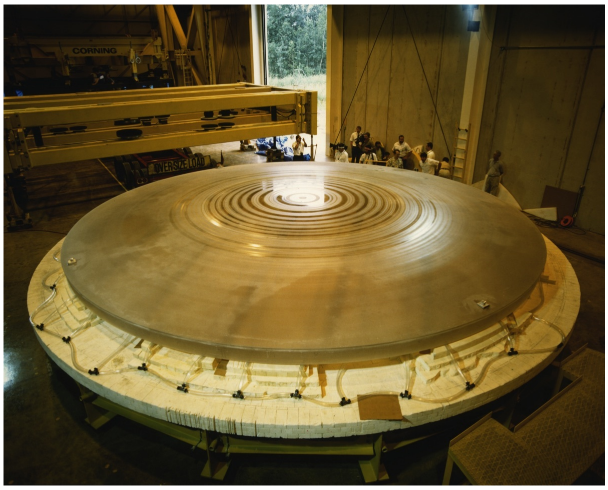


Forty four hexes are arranged to make 8 m plate.

Then fused in a furnace to make 8 m mirror blank.



One side of mirror blank is polished before sagging down.



Sagged down mirror blank in the factory of Corning.

When I first saw the blank, the convex mirror blank was on the furnace and it looked like a plate laid there upside down. The semi-transparent amber-colored ULE large plate looked smaller than I expected. It was because I was looking the glass in front of me laid there horizontally. The thickness of the glass blank I was watching impressed me, and made me think that it is massive. Before I saw it, I feared it might be fragile. I joined Mr. Miyashita who came from Hawaii and Mr. Kinoshita of MELCO and checked the mirror blank. I took off from me everything that may fall, climbed on the mirror blank covered partly by vinyl sheet, and used special magnifying glass to watch inside of the blank. Small bubbles could be found here and there. The light put below the mirror is observed to be in patch. Stress inside the blank causes difference between two polarized lights and causes those patches. I sweated as I put a dust-free cap on although it was hot and humid. But I continued to watch with the magnifying glass lying flat on the mirror blank.

“How is it?”

asked an engineer of the Corning Glass Works. But I could not answer properly as I am not a specialist.

“Uta, do you wish to see it?”

Uta in turn climbed up the mirror and held the magnifying glass. In the meantime, I began to feel the scale of the mirror. The factory was large and a crane ran at quite an elevation. At the end of the rectangular building, there was a truck for the transportation half inside. At the center of the factory, the main mirror blank of Subaru Telescope was sitting there, and on the other side of the building, a furnace for the next large product was assembled and the upper structure of the furnace with many gas burners were hanging from upward.

“A trouble came up. The engine of the tugboat of the large lakes is not good,”

said Mr. Kinoshita coming up to us with serious countenance. Our large main mirror blank was planned to be transported first on a trailer to the St. Lawrence River. Then, at the harbor, the trailer with the blank would get on board of a river-boat. A tugboat would tug it to the Lake Ontario, then to the Lake Erie. From the Lake Erie, the truck would head to the polishing company through the Interstate Highway. Between the two lakes, the boat would go through the Welland Canal beside the Niagara Falls. As to the land transportation, it was necessary to get the permission of the state police 48 hours before it as the public transportation would be shut out of the highway.

‘What a blunder that the engine of the tugboat has trouble. They must have chartered quite an old one.’

I was recollecting the story of transporting the mirror described in ‘The Glass Giant of Palomar.’ At that time, the mirror was loaded on a special car (well-car) to cross the Continent of America from Corning, New York to Pasadena, California. Tunnels were the hardest of all to clear with the mirror on the well-car.

Personnel of Corning Glass Works, the glass maker, Contraves of Pittsburgh who polishes the mirror, and the main contractor MELCO were discussing the problem quite a long time. Staff of Iwanami Filming Company who came here to film the ceremony of shipping and we together with the local news people and spectators who came a long way waited the results of the discussion.

“The wife of the driver of that large trailer is a locomotive engineer of the Amtrack,”

Uta reported to me the information she got during an interview which I was unaware of.

“The trailer is his own. He registers at a company that helps jobs, and gets contract. Usually, he transports big items crossing the border between Canada and U.S. He puts an item so big that it cannot cross a bridge on his trailer, then on a river boat to cross rivers and lakes. This is not his special transportation.”

According to her, he had a license of a driver, but he had also a bachelor’s degree in engineering and had a license of a mechanical engineer. The axles of the trailer are equipped with oil pressure mechanism and their heights are controlled independently of other axles. This allows his trailer to keep the truck horizontal even if he is driving a rough road. He did the maintenance of the mechanism himself.

“O.K. I got that he is an able man,”

and I was trying to remember his hippie-like face with beards. I wanted to see his wife if allowed.

After long, long discussions among the three parties, it was decided to hold the ceremony. The start of transportation would be delayed by one day, however, the representative of the Corning Glass Work had already left New York and was heading to Canton. So was the representative of MELCO America.

In the afternoon, a little later than scheduled, a platform was prepared close to the mirror blank in the factory, and the ceremony was held. We, the guests, were asked to have seats on the platform, and some forty or fifty people of Corning Glass Works who worked for the fabrication of the main mirror blank gathered together. I could see joy and pride in each face attending the ceremony.

‘Soon, this blank will be polished, assembled in the telescope, and gazes the Universe. I wish that the mirror as the world’s largest monolithic glass mirror will give us the sharpest image, that the mirror will give us the wisdom of the universe, that the mirror will not break before it is completed.’

I was praying with these words without voice. Engineers of Corning Glass Works knew glass thoroughly. They said,

“Glass won’t break if handled properly,”

and looked very trustworthy. Certificate of thanks was presented to the company, and a shield of thanks was presented to the chairman of the local labor union.

“This is important in order that good jobs are done,”

said the director of the factory. ‘Responsibility is to the director, glory to all,’ was the idea. The chairman of the local labor union sent me later a bottle of maple syrup locally made.

After the ceremony, work of moving the eight meter mirror blank into the container on the trailer started. Corning workers were trained well for this kind of job. A man who worked for the Palomar mirror when he was a young apprentice was commanding the job.

“Lower the crane!”

the man who looked like a true workman raised the voice with his both hands at his suspenders. About twenty people in the team got their positions immediately. I was struck with admiration by the fact that so many human eyes are used in this job where crane and vacuum attracting plate are controlled remotely automatically. Four vacuum attracting plates of one meter size came down and landed slowly near the center of the mirror blank. Hangers were fixed to the band surrounding the mirror blank, and it seemed to me that a large steel frame hugs the mirror blank in. It took quite a time to check the fixing and the forces.

“Lift it a little!”

a loud voice echoed in the quiet factory. Again, careful check was done, then it was lifted a little more, then careful check again. Finally the large mirror was in the air. Then, ovation started from everywhere. The crane moved slowly upward, then moved horizontally until it came just above the container, then moved slowly downward. The mirror blank was then lowered very slowly. When its bottom was a little lower than the upper edge of the container, the work stopped. They were making many checks there. Thirty minutes passed, one hour, then one hour and a half. Workers started to become noisy. A Contraves man in charge of transportation was clinging to telephone talking to someone in his company.

Mr. Kinoshita with somewhat pale countenance brought back information;

“What a surprise! The blank won’t go into the container. The triangular packing to stop vibration was fixed wrongly.”

“Eh! Oh, I felt that something was wrong within the container although I could not specify what it was.”

I could not continue after that. When I inspected, I had a hunch that the shape of the packing rubber at the eight corners of the container was a little bit strange. The slope of the side that touches the side of the mirror blank seemed to be too large. The blank was first made flat, then sagged down. Therefore, its side may not be exactly vertical. But I saw the sides when I climbed up on the mirror. The departure must be very small, if any. I thought,

‘What a fool to put the stopper rubber in a wrong direction! We were paying attention not to do a large mistake, so came such a trifle error. It was good that such a small error was causing this,’

but I could not say it.

“Start lifting!”

a loud voice echoed. Then the mirror blank went backward the trace it followed, then it was lifted down calmly on the convex mold in the furnace. It was already night.

“Special rubber is adhered with special agent, so it cannot be pulled off. They start cutting them off tonight,”

Mr. Kinoshita said. He was the herald. Camera people seemed to be used to this type of happenings, and went back to their hotel calmly. When the tension was gone, my stomach started to ache.

Next day, another problem arose. It was necessary to file for the permit of transporting large load 48 hours before transportation. The schedule was already postponed by one day, but another delay was necessary. New delay means two additional days of delay. Then, we were informed that the engine of the tugboat can not be repaired, so a new boat was chartered. Finally, the shipping was delayed by one week.

A party celebrating the completion of the blank and acknowledging the effort of all the people involved was held as scheduled that day in a hotel on the riverside of St. Lawrence. If the shipping went out without interruption, we might have seen the mirror blank on a boat moving by the hotel. A plan to follow the boat in a yacht had to be canceled, but the Corning people were pleased because their job ended. A little before the start of the party, cloud thickened, then it rained in torrents as if the bottom of the sky was broken. Beautiful England-like scenery was wiped out by the splash of water, and nobody thought of getting on board of a yacht.

“This kind of things happen. Do not be excited by these happenings. But all kind of things happen so many times in our journey,”

Mr. Kinoshita said with an air of consoling me.

Uta and I did not wish to wait doing nothing. So we decided to visit the polishing factory of Contraves in Pittsburgh before we leave for Japan, and changed our itinerary from the next day. The large old lime mine was renovated with a new thirty meter high vertical shaft, and a large polishing machine from Germany was to be installed there. The cave factory that I have seen once several years ago, was extended and became wide. They were giving the last touch to it taking care of the water leaks.

‘A fine glass blank is ready now. Please inspire a soul into it. Make it the top of the world mirror,’

I bowed my head to the President of the polishing company and the director of the factory that night. They were one of the party whom I asked for cooperation for years making surveys without funding. Recently a contract was signed between this company and MELCO, and the work for our mirror started. A special order of a large polishing machine was sent to Schieth & Company in Germany. Dr. Scott Smith was not there as our visit was not a scheduled one.

“We know that. We have taught our men repeatedly, so be assured of that,”

the director of the factory said.

“But you are not allowed to make a mistake of the kind that happened a few days ago. Be sure that you take the wisest measure. I presume that the man in charge was doing his best.”

I pleaded for him, but he was fired soon afterward. A post in U.S. requires severity. Recently, the bubble in the economy popped in Japan. In U.S., depression started one step ahead and every company was starting re-structuring of its organization. The end of the cold war made the military related works decrease markedly, and many companies were trying to cut their employees. Contraves was not among the exception. The chief optical engineer, Dr. Scott Smith, was there since long time, but many staff whom I got acquainted with during the survey period were gone, and other people substituted their jobs. I wished if every company follow the path of Corning Glass Works with the spirit of “Let’s make the best mirror in the world!”

A little after I returned Japan, a report came from Mr. Miyashita who continued to stay there. While waiting the shipping, he visited the company in Vancouver who contracted the iron works for the dome building. After the trailer left Canton on a river-boat, he accompanied the boat in a car making telephone contact with the boat. The data of the acceleration meter were sent by wireless radio to the monitor in the accompanying car. When the boat passed the Welland Canal, an atmospheric depression was coming close, which made the decision of leaving the port late. The delay in the schedule was not properly transmitted, and the permit to pass the state highway of Pennsylvania State was not obtained in time, which made the arrival two more days late. Pennsylvania state police used the short-wave radio so that public get well aware of the change of the schedule and broadcast, "Do not drive your car into the restricted portion of the highway."

Then a number of cars rushed there so that they can have a look at the transportation of the largest mirror in this century, which made the traffic control very difficult. Most causes of delay were unavoidable. However, transportation took many more days than anticipated. This posed a problem for later works. Mr. Miyashita, though tough he was, seemed to be quite tired. Uta, however, was glad that she could touch the actual eight-meter blank, of which she had only heard for a long time, and said,

"You held firm, it is true. But, I held firm, too."

In this large telescope project, many observatory staff and their family held firm.

Route of mirror blank from Canton, New York to Pittsburgh, Pennsylvania.


Mirror blank is lifted up.


and is put into the container.

Truck leaves the Canton factory of Corning.

Then on board of a river-boat through the Lake Ontario.

Through the Welland Canal,

across the Lake Erie,

then through the highway to Pittsburgh.

6.3

This year for the first time as the director, I submitted the budget request for the next fiscal year. Accompanied by an officer of the observatory, I met officers of the Ministry of Education in charge and explained the basis of our budget request. By a lucky coincidence, my work was alleviated by a large amount. My second daughter was working as a TV caster and was well-known, so I introduced myself with,

"I am the father of Keiko-Annette, the sports caster of NHK TV, News Seven."

This saved one explanation. Adding to this, 'An Astronomical Show of the Century,' collision of the Shoemaker-Levy's 9 comet with the Jupiter, happened. TV programs were filled with that news. In ordinary years, I had to explain the importance of astronomy, but this year I could dispense with that.

In the Solar system, there exists many asteroids. They are small lumps of mass that failed to become a planet like the Earth. Smaller ones fly around as comets. Most asteroids gather together between the orbits of Jupiter and Mars, but some of them come close to our earth. Comets are lumps made of snow and sand. They come from the outskirt of the planetary system where the solar light barely reaches. If one lump happens to fall inside, it is heated and a part of it vaporize and become a comet with a tail. If it's orbit is affected during its fall to the Sun by the gravity of a large planet like Jupiter or Saturn, it becomes a periodical comet that moves around the Sun. Both asteroids and comets are important celestial bodies for the study of the history of the Solar system.

But if it is going to collide with the Earth, it will cause a big disaster. Small dust grains burn away in the air as meteors. The Shoemaker-Levy 9 comet had a size of Mount Fuji. Its energy at the time of collision is comparable to billions of H-bomb, so it has a power to destroy the biological environment on the Earth. The Shoemaker-Levy the Ninth comet broke up into more than twenty parts when entering the gravity field of Jupiter, and collided with the Jupiter in turn during the spell of one week and made gigantic mushroom clouds. Astronomers in the world observed this event for twenty-four hour per day basis. News media reported the event as top news. Every people in the world had to be interested with astronomy whether he liked it or not. For Japanese people, this was specially so as the first calculation of the orbit announcing the collision was made by a Japanese amateur astronomer Mr. Shuichi Nakano. Mr. Nakano later received a letter of thanks from the Minister of Education Mr. Yosano.

The Subaru Telescope Project, the Japanese Large Optical and Infrared Telescope project known only to the interested researchers in the early phase, was now known in and out of this country, and the numbers of people interested in the project was increasing rapidly. Thanks to the astronomical images provided by the Hubble Space Telescope (HST) that was actively working for these years, people were more interested in the universe than before. It was completely different from what it was twenty years ago. A Japanese astronaut was on board of a space shuttle. In old days, a report on astronomy was printed in the science page of newspaper only when there was a big event. Now it appears on local pages and even on the top page. As the Japanese community got rich, people got room to think about such things. It was the same as flower pots started to appear in front of houses. 'Astronomical collision show' was followed by the comet Hyakutake with beautiful tail decorating the northern sky. This comet discovered by an amateur astronomer in Kyushu Island Mr. Yuji Hyakutake was not so big by its size, but it shone brilliantly because it came close to the Earth. The Emperor and the Empress expressed their wish to visit the observatory to see the comet. We prepared for their visit, but that very day it was cloudy and the royal visit was not realized. In order to meet the demand of people, National Astronomical Observatory set up a 'Public Relations Office,' made a fifty centimeter telescope open to public, and made a nation-wide communication network of public observatories to share information of astronomical images. The demand for this kind of work grew endlessly, so we anticipated very hard work for these outreach activity.

Dr. Jun-ichi Watanabe who took the directorship of this Public Relations Office and its staff devoted themselves to these works.

Certain buildings and hills are normally 'lighted up.' As the big comet approached, 'light down' of such buildings and hills campaign started. The campaign aimed also at making street lights and neon lamps darker so that we get the beautiful night sky back. It economizes energy. Some of us are living with day and night interchanged. It will also help them to get the natural rhythm. Environmental Agency started to cooperate. By the way, in the Island of Hawaii, a law was established to keep the darkness of the night sky of this 'World No.1' place for astronomical observation as a result of a campaign that the Institute of Astronomy of the University of Hawaii started.[1] It requires that lighting outside should be orange 'low pressure sodium lamp,' and the lighting appliances should have lamp shades of such structures that they allow only downward light. The last lines of this ordinance describe the penalty in case of violation. The merchant who sold such lighting appliances are also fined penalty. Astronomers prefer that the night sky is always dark, but we cannot force our preference to ordinary citizens. Lighted-up TV tower is as beautiful as the star-lit sky. Difference is that looking at the lit-up TV tower may not lead to the thought on the destiny of the indispensable humankind and the Earth. When looked down the night-side of the Earth from the artificial satellite, the brightest region is Japan. It means that waste energy is emitted to the sky. If the Earth is observed in detail from other stars, the region of Japan may be the brightest part of the Earth in the visual light as well as in the radio-wavelength. They may find out that the Earth rotates in twenty-four hours as its brightness varies periodically.

While Comet Shoemaker-Levy 9 was approaching the colliding orbit in the sky, an astonishing phenomena of the birth of the coalition cabinet of the Liberal-Democratic party and the Social party happened on the Earth. Mr. Tomiichi Murayama became the Prime Minister. What was called as ‘1955 political system’ became completely to an end.

“What a change!”

I had to remind me of the night when students broke into the Diet building during the Fight against the Japan-U.S. Security Treaty.

That year, Uta and I made a trip to the countryside of Korea. It was just before the fiftieth anniversary of the End of the War. I have several friends in Korea. But Japan and Korea have uneasy relations. They are quite different from those between Germany and its neighbor countries. Korea at present seemed to us to be the peace itself. Walking along the country road of Buyeo (扶余), I felt as if I am walking along Yamato-road in Nara.

‘Is there anything really Japanese other than the mixture of the things and culture that came from the continent, Korean peninsula, islands in the south, and across the Sea of Okhotsk?’

It seemed to me that 'mixture' is itself what is Japanese. Coalition cabinet of Liberal-Democratic party and the Social party seemed to be one of these Japanese phenomena.

I suffered from chronic stomachache since long time before we went to the ceremony of shipping of the mirror blank in Canton. During the retirement party of the ex-director Kozai, I had a sharp pain after I talked about his achievements and I almost fainted.

'I have to see a doctor by all means. It is also a duty of a man holding the director's chair. It may happen that I am suffering a serious disease and I may have to be hospitalized on that very day.'

Uta and Aiko were observing me in such a state for a very long time and had already made an appointment at the Toranomon Hospital after having consulted with a doctor in the hospital where Aiko worked. After many examinations, it turned out that I had 'stones in the bile duct.'

'That happens to many people. For the time being, I bend my body when I suffer,'

was what I thought. The doctor said,

"You are in an urgent state. You have to be operated immediately."

It was close to December that I was hospitalized after many postponements. Fiberscope was put into the mouth until it reached the duodenum and bile duct. He cut the entrance and caught the stone inside. This operation did not go well, it seemed to me, and the stone was broken into two, and one piece was left inside. Moreover, the entrance of the bile duct was cut more than it was necessary, which caused pancreatitis. I got fever, and the temperature did not come down. Hospitalization was first scheduled for ten days, but it lasted for three weeks. After pancreatitis was gone, the remaining stones were caught out. Still slight fever remained. Although doctor's intention was

'Let's take the bile out when your temperature is gone,'

I left the hospital of my own free will. It was close to the end of year. I thought it is all right that the bile be taken out later after the New Year. The sharp pain did not come back again.

In January, a great earthquake attacked Kobe. On that very day, I planned to go to the Okayama Astrophysical Observatory to make a New Year greeting and have a meeting with the staff. I had already booked a seat of Shin-Kansen (New Bullet Train) to go there. The morning news, however, informed that Shin-Kansen is stopped because of the earthquake. I watched the news until noon, but the damage was far greater than I had thought first. I could not expect the recovery of the railroad. In order that I could come as close as possible to OAS, I reserved a seat on a airplane to Hiroshima. It was at midnight of that day that I reached OAS. Kobe was in a desperate state. After about one week, Uta went to Kobe. News of the earthquake reported through Radio Japan by her was responded by donations from many European listeners. She wanted to give the donations to the German school through the Consulate of Germany in Kobe. Most foreigners already left for their mother country, but the Consul of Germany did not wish to leave Kobe and stayed in a hotel.

In August, I got the operation of taking the bile out. Michelle Aiko did not attend the operation. She left Japan for U.S.A. already in March after the Sarin case, and was already a graduate student of the University of Maryland. She could not accept the status of nurses in Japan and wanted to study 'terminal nursing of patients suffering from cancer' in the United States of America where she was born.

---

[1] Hawaii County's Outdoor Lighting Ordinance, Chapter 14. GENERAL WELFARE, Article 9. Outdoor Lighting

6.4

The Subaru Telescope Project progressed steadily while I was busy with the director's work. Subaru Project Office in NAOJ had Prof. Kaifu as the project director, Dr. Iye as the project scientist, and Dr. Karoji as the project manager. Daily works of the project office were supervised by Mr. Noguchi and Dr. Masahiko Hayashi. Prof. Tetsuro Nishimura, an expert of instrument development, came from the University of Arizona. Dr. Kazuhiro Sekiguchi came from Cape Town Observatory of South Africa. He had a lot of experiences of astronomical observations. The project office was filled with these staff as well as many other young enthusiastic astronomers. I asked Prof. Nishimura and Dr. Sekiguchi to move to NAOJ particularly for the Subaru project. Drs. Masahiko Hayashi and Saeko Hayashi, and Prof. Yoshihiro Chikada moved to Subaru Telescope Project from the field of radio astronomy. Prof. Chikada had a talent of creating brilliant ideas for a given situation. He built a team of computer technology that includes development of software and made it work fine. Fortunately, personnels that we thought necessary for the project were admitted. Persons concerned of other departments of the University of Tokyo envied us,

"We suffer from the reduction of personnel of budget base while the Observatory gets three or four new staff per year."

Certainly, things happened as they claimed. NAO was of course assigned the even rate reduction of personnel, but we got more personnels so that the total number of staff increased by three or four every year.

I tried not to look in the Subaru Project Office suppressing my desire to take part in the project.

'I left the project's activity to the staff. Young people are doing their best. I will do my best as the director of the observatory. That is what they require of me.'

However, I visited Subaru Project Office once or twice a week for the lunch break. As the number of people increased, sitting space at the table were too cramped for comfort. Dr. Wataru Tanaka came there everyday for lunch-break. Female part-timers were there of course. Mrs. Tei Masuyama of the director's room joined. It was my pleasure to get informations of the construction on the summit and the progress of the mirror figuring. Of course, I knew them by reading the formal report of the Telescope Committee. But the words from those who are working on particular items were vivid and had warmth.

Mr. Noguchi delivered me diligently hand-written draft of the report of meetings with the manufacturer that were held quite often. And ‘Weekly Report’ came from the temporary office in Hawaii, and its copy was delivered to the director’s room. Those who came back from an official trip to Hawaii came to the director’s room and reported the recent situation.

Dr. Nariai was the Representative of the Subaru Project Office and was living in Hilo, Hawaii. Mr. Nakagiri was living in Hilo, too. Mr. Okida or Mr. Miyashita was the third Subaru Telescope Project staff in Hilo. Either one of them was on a long-term trip of several months to Hilo. Besides these three, young Subaru Telescope Project staff began to visit Hawaii. The temporary office in Hilo started as one desk in the Hilo office of the Institute for Astronomy, the University of Hawaii. Now, we have a contract with the Hilo Hotel to rent a room in a separate building and have a certain level of facilities. However, as Dr. Nariai and Mr. Nakagiri were there as Japanese staff on long-term trips, difficult problems such as account processing and/or to whom the responsibility of such and such deed belonged.

Gradually, the number of local employees began to increase. Local employment was done through a special corporation for cooperation of research, the Research Corporation of the University of Hawaii (RCUH), an affiliate to the University of Hawaii.

The University of Hawaii itself is run by the State of Hawaii and its employment is strictly regulated by laws and rules of the State. So, the State of Hawaii inaugurated a system in order to secure flexibility that is required for education and research.

Dr. Fujio Matsuda, the ex-president of the University of Hawaii, gave us careful instructions. This corporation will be responsible for this employment but the selection of people and the direction in the office are left on our hands. Observatories of other countries on Mauna Kea use this system.

‘Can we match the Japanese style office atmosphere with the corresponding American/European one?’

This was still unknown to us. Fortunately, the first few local employees spoke

Japanese fluently and we did not have lack of communications.

Design and development research of observational instruments of the Subaru Telescope started to advance. Prominent figures like Dr. Toshinori Maihara of the Department of Physics, Dr. Hiroshi Otani of the Department of Astrophysics of Kyoto University, Dr. Shuji Sato who moved to the Department of Physics of Nagoya University from the National Astronomical Observatory of Japan, Dr. Sadanori Okamura of the University of Tokyo were involved in these tasks. However, it was necessary that staff of the National Astronomical Observatory of Japan, Drs.Ando, Iye, Tetsuro Nishimura be in the groups for big instruments in order to make the projects proceed. A new division 'Center for Development and Experiment of Astronomical Instruments' was led by Dr. Yukiyasu Kobayashi. Thanks to his hard work, several groups for engineering development started to grow. But the development of astronomical instruments in Japan was still at its starting line. In the field of radio astronomy, a certain engineering developments such as detectors excelled all others in the world. This excellence in the engineering field was limited only to the Nobeyama Cosmic Radio Astronomical Observatory. The situation was so in the National Astronomical Observatory of Japan. Situations in the universities were worse. Dr. Tetsuro Nishimura who knew many advanced places in the world must have been impatient, I presume.

Dr. Alan Tokunaga of the University of Hawaii made an offer to me saying,

"I can take charge of one infrared observational instrument."

The National Astronomical Observatory of Japan invited several foreign researchers as visiting professors in order to promote Subaru Telescope Project. Dr. Tokunaga was one of these visitors. Among the visitors were Dr. Larry Barr who was the chief engineer of the National Optical Astronomy Observatory of U.S.A. and Dr. Peter Gillingham who was the engineer in the field of developing instruments of the Anglo-Australian Astronomical Observatory. As Dr. Tokunaga was working with Japanese astronomers for some time in observations and in instrument developing, his offer was received quickly. It was agreed to send young people from Japan to the

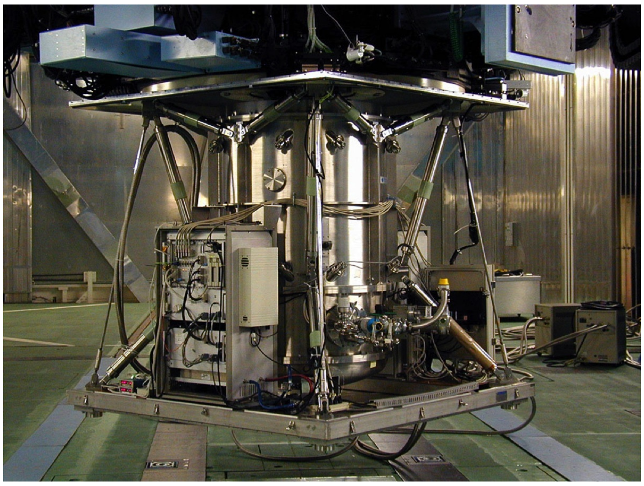
University of Hawaii so that he can work with them in development and fabrication of the instrument. He is an American of the Japanese ancestral origin of the third generation (Nikkei Sansei), and was at his early fortieth. He is a good guy of Asiatic looks with black eyes and black curly hairs. Although his facial muscles are American as he grew up speaking English, we had friendly feelings toward him. His taste was very much Japan-oriented. He loved hot-springs (onsen) of Japan. It was of great help to us that he faithfully took part in the meetings held in Japan. As Japanese was used in the meetings, he needed an assistant sitting next to him so that he could understand what's going on. By this time, Subaru Telescope team grew very much and it had many talented staff that there was no lack of such an assistant. Dr. Tokunaga loved Japanese style friendly parties (konpa : student's jargon, abbreviation. of company). One day, we had a konpa of about thirty participants in a Japanese style room of about twenty square meters of a nomiya (=Japanese style small restaurant) after the formal party of an international conference. When we got out of nomiya after the konpa, most participants could not walk properly because of having been in a tight place for a long time. But Dr. Tokunaga seemed to be satisfied as he said

"Well, we had an enjoyable night. Haven't we?"

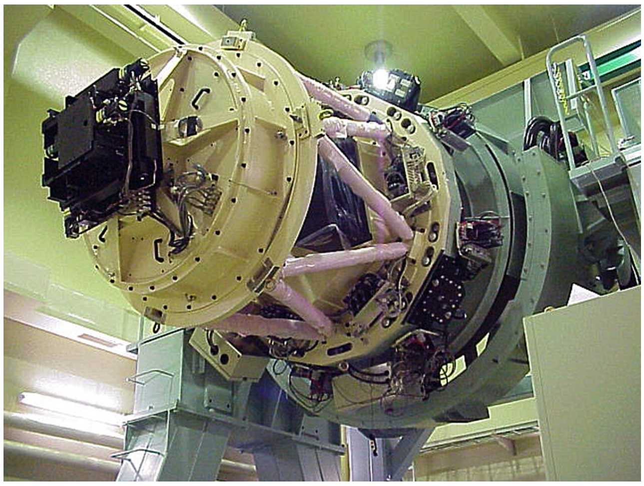
It seemed to me that the cooperation with the University of Hawaii would proceed smoothly thanks to the presence of an optimistic man like him.

Explanation for the budget request of observational instruments was more difficult than that for the telescope itself. Everybody knows what a telescope is. Kansoku sochi (observationnal instrument) is not known as a telescope is, and is thought something extra. But the truth is not so. It is no exaggeration to say that it is the heart of the telescope. If we treat lightly of Kansoku sochi, Subaru Telescope won't work properly.

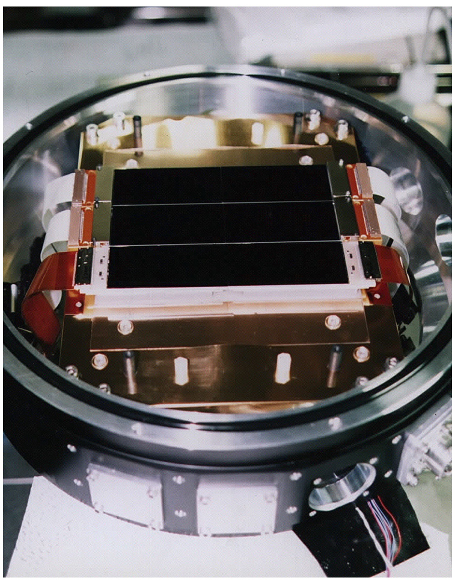
A telescope concentrates light from celestial bodies into sharp images. Observational instruments receive the light from the telescope, records and/or analyze it. They are designed and fabricated so that the target of research is reached. When doing a high-tech research, it is necessary to make a new break-through using the latest technology and making developmental research. Researchers must have full understanding of not only astronomy but also engineering. Optics, semi-conductor engineering, electronics, etc, etc. Moreover, computer engineering and software engineering are having more and more weight than before. It is hard to cover all the area of science and engineering by only one person. Anyway, people that are called as astronomers think of the universe as they like. It is not rare that their requirements or specifications for observational instruments are higher than ordinary ones by orders of magnitudes. Engineers of manufacturer are urged to have spirit to get over the difficulties shown to them. Many Japanese manufacturers such as world famous optics company Nikon and Canon, Hamamatsu Photonics known



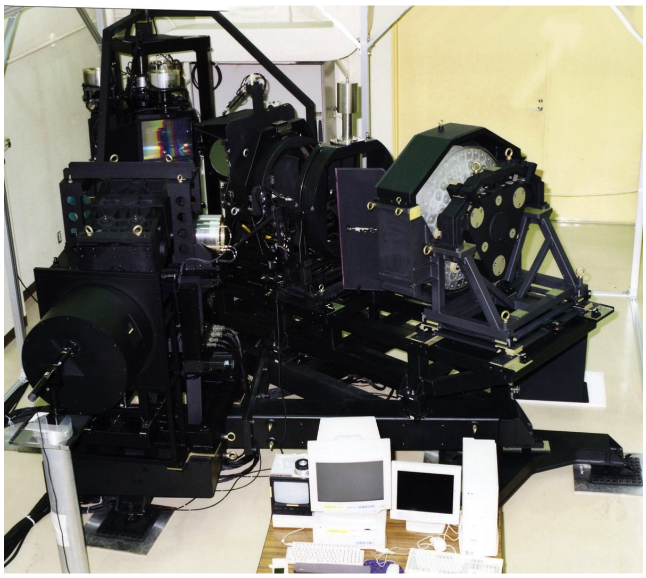
COMICS. Cooled Mid-Infrared Camera and Spectrograph.



FOCAS. Faint Object Camera and Spectrograph.



Suprim-Cam. Mosaic CCD camera of Subaru Prime-focas camera.



HDS. High Dispersion Spectrograph.

worldwide as the top-level company in detectors, Sony, Fujitsu,...., they entered the engineering race of Subaru Telescope. Telescope technology levels up by innovation with the time-scale of half or quarter of a century. But the progress of technology of semi-conductors and communication is more rapid and may be called Nissin Geppo which is a Japanese phrase that means 'rapid and steady progress.' In order to perform first-class observational researches with the first-class telescope equipped with the first-class observational instruments, we have to perform developmental researches for the next generation instruments while making observations with the instruments just fabricated.

One candidate for the next-generation instrument is 'Spectrograph for many celestial objects.' This instrument is composed of a terminal device of optical fibers placed at hundreds of images of celestial objects on the focal plane of Subaru Telescope and a spectrograph at a different place that receives light through the fibers. Optical fibers at the input terminal are scattered on the focal plane, but they are re-arranged on one line before they enter the spectrograph so that it can take spectrograms of several hundreds of celestial bodies at one-time. A plan of making such an instrument with international cooperation is investigated with Dr. Karoji as the leader.

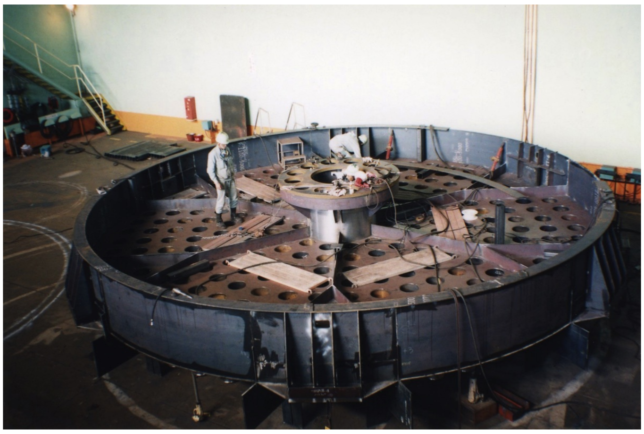
These topics made my 'work of research' revive, and I almost said something to contribute to the progress of these project. I had to do the jobs as the director of the observatory. Besides judgements and commands from a wider view of things as the director, I had many settlements on transactions and everyday chores to do. I got a little accustomed to them, but they were still painful to me.

In autumn of 1995, 'shop erection of the mechanical structure of the telescope' started. It was in the second year after I moved to the director's office. Huge parts cast and welded with greatest care in Kawatetsu Machinery on the Setouchi Coast (Inland Sea Coast) or in Sakurajima factory of Hitachi Zosen (shipbuilding) were collected and made into one body. It took several days to anneal big parts that are 10 meter big for which relative allowance of warp is only several micrometer. We called these works as 'precise heavy industry.' Mechanical structure of 20 meters high and 400 tons of weight is assembled in Japan and is tested for the operational performance. If the result is good, it is de-assembled and is sent to Hawaii. It took long time for the search of a factory appropriate for this work. Sakurajima factory of Hitachi Zosen had many assembly factories for large mechanics near the wharf. At last, we decided to use the biggest space of this factory with sagging down a part of the floor.

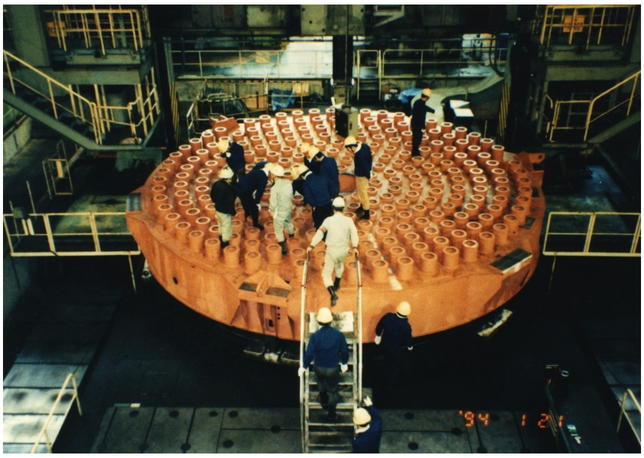
We put our most effort on the developing research of actuators. Three hundred actuators were completed and were installed in the supporting structure of the main mirror and were waiting for the total performance test. It was a gorgeous view to see the real actuators in front of us that we have seen on a plan in the past. We had many many meetings for this purpose and staff of the project office visited the factory site many times. In November, the ceremony of the completion of provisional assembly was held and TV and other mass-media reported for the first time Subaru Telescope in movements. Subaru Telescope was huge. Although the main mirror of eight meter diameter had not been installed in the telescope yet, the huge telescope tube moving smoothly without making noise reminded me of the fact that within a few years we will see its powerful ability. At the same time, I was recalling the long time we worked for this project.

'I sincerely thank them who payed efforts to bring the project to this stage. But there is a proverb. Ninty nine miles is a halfway to one hundred miles! Real work starts now. Tighten our mind! I hope that all the staff do their very best until we reach the real goal.'

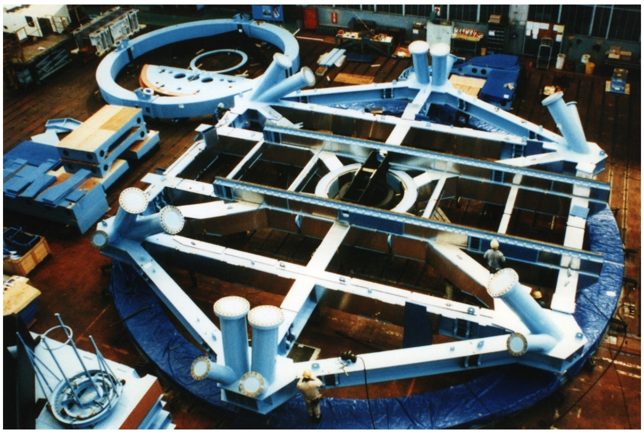
When the new year started, a fire broke out in the Subaru Telescope enclosure under construction on top of Mauna Kea as if my anxiety took real form. That year took a bad start from the beginning. On the forth of January, Uta went to Korakuen with our daughters to enjoy skate boarding, was hit by an elementary school boy



Mirror Cell.



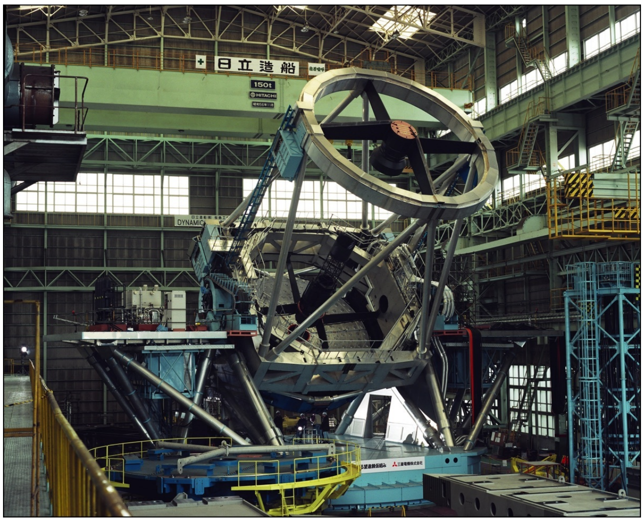
261 actuators were to be installed in the supporting structure of the main mirror.



The upper part of the center section of the telescope.

Telescope mount. Two tripods are ready to support the elevation axis of the telescope.

The top ring is lifted up. It will be moved to the left and will be put on the Cerrurier Truss structure.



Subaru Telescope is pre-assembled in the factory.

from behind, and had her wrist broken. Fortunately, she received emergency treatment. But she had to leave for Germany in order to have rehabilitation. The first two weeks of the new year passed busily like this. When I was doing my jobs in the director's room on the morning of January 17th, one year after the big earthquake of Kobe, the first report from Subaru Project Office came.

"A fire broke out at the construction site on the top of Mauna Kea. Casualties are expected."

An office to respond the accident was set up immediately in order to collect informations and and to cope with the situation. But we could not get related informations as we expected. Staff of the temporary office tried to do their best, but the situation did not become clear to us quickly. It was evident that liability and compensation issues will come up soon, so everybody hardly spoke about the accident. No matter whomever we asked, the answer was the same,

"Wait what comes out by the investigation of the police or the fire-department."

Hospital staff were the same. Subcontractors who are doing the construction work are the most cautious of course.

Spark of welding machine caused fire. As the building had a tube-like structure, fire at the lower-most part ran up the wall quickly to the upper-most part. Because of the thin air, a lot of smoke was created and filled the dome. A large sliding door was opened, but those who were working at the top part of the dome were attacked by the smoke, and this accident turned out to have three casualties.

Burnt-out material loss was not much. But damage by the smoke extended to large area and it was not easy to make-up the recovery plan. Moreover, we were most sorry for the losses of human lives for which we could not regret too much. All three of them were residents of the State of Hawaii, and were employed by the subcontractors of interior decoration. I wanted to fly over to Hawaii to offer my condolences to the families of victims. But I was forbidden to do so. First of all, this accident took place during construction. Our observatory was not directly responsible for the accident. I was not allowed to see the site of fire until the investigations by the related local agencies and insurance companies were over. But the project director Professor Kaifu left for Hawaii immediately. I could visit Hawaii in the end of March, two months after the accident.

At the time of fire breakout, many people of neighboring observatories rushed to our dome for rescue and fire extinguishing activities at the risk of their lives. Especially, if it had not been for the help from Keck Telescope, our closest neighbor, damage must have been more serious. I had to visit the neighboring observatories to express sincere thanks for their help.

Subaru Telescope enclosure was shining triumphantly with the blue sky on its back. When I walked in inside of the dome, I noticed the walls were stained black with soot. At the lowest part near the floor, only a small part was black. The black part spread widely as I looked upward. At the highest part, the crane floor, the entire wall was stained with sooth. It was a cruel scene. Study of the recovery plan was almost done. Construction work would resume as soon as the permission from the authority is obtained.

Issue of compensation negotiated between the company and the families of victims was progressing. I had to leave Hawaii without seeing the families of victims. In the dome of Keck Telescope to which I dropped in in order to say words of thanks, I saw thirty six segmented mirrors shining brilliantly, which made me a little envious.

On top of mountain, construction work was delayed by the accident at the site. In the Hilo city at the foot of mountain however, the construction of the base facility of Subaru Telescope started. I attended the ground-breaking ceremony as the director of the observatory. The base facility of Subaru Telescope is constructed in the area called 'University Park' at the corner of

The ground-breaking ceremony for the Hilo Base building.

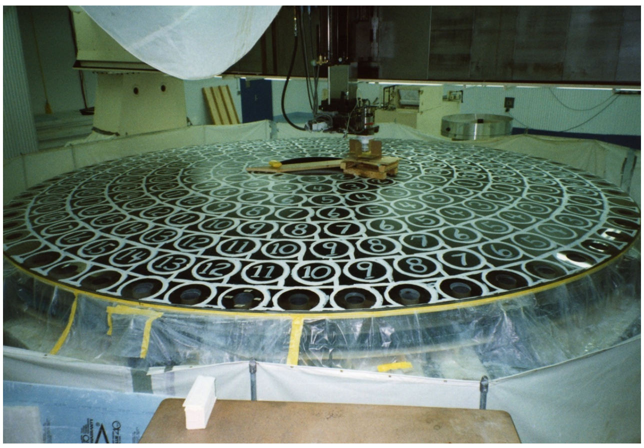
the Hilo campus of the University of Hawaii in the city of Hilo. There are base facilities of the Joint Astronomy Centre of the United Kingdom, Canada, the Netherlands and of the Caltech Submillimeter observatory of California Institute of Technology. The Institute for Astronomy of the University of Hawaii planned to construct their offices here. Development of this area is proceeding under a plan of making this area a big capital of astronomy. Gemini North which is being constructed at the top also plans its base facility here. Agreement with the University of Hawaii for the base facility is almost the same as the one for the facility on top of the mountain. Rental fee is one dollar per year. It is written in the agreement that cooperation in the field of research and education be promoted. After the completion of construction that takes two years, a team of NAOJ staff of about thirty people composed of officers, engineers, and researchers will stay there and make the telescope run.

Subaru Telescope will be located next to Joint Astronomy Centre. On the other side, the building of the Institute for Astronomy of the University of Hawaii is planned to be constructed. The city of Hilo extends from the seashore to the foot of mountain. Hilo Campus of the University of Hawaii is located close to the foot of mountain. From the University Park located on the mountain side of the Hilo Campus, we can command a view of reddish buildings of the University through the green trees, and beyond them the Hilo Bay and the Pacific Ocean. Buildings of the Japanese base facility are designed to have modern looks with concrete and glasses and give a different atmosphere from those of the adjacent buildings. The two-storied Research and Experiment building houses computer room and many laboratories. Among them are Subaru Telescope simulator room where observational instruments carried into are checked for the final test before they are carried up to the telescope facility on the top of Mauna Kea, and 'the remote terminal room' where activities on the top of mountain are checked and, if necessary, commands can be sent from it. Network will be connected across the Pacific Ocean to the main campus of NAOJ in Japan and to the main universities in Japan.

By the way, Keck Observatory has its office in Waimea because the owner of the Parker Ranch famous for being a millionaire donated the land there. Moreover, the Keck Foundation that contributed to the first Keck telescope donated fund for the second telescope so that the two telescopes can be used as an interferometer. So, a powerful observatory was going to be realized with private funds only.

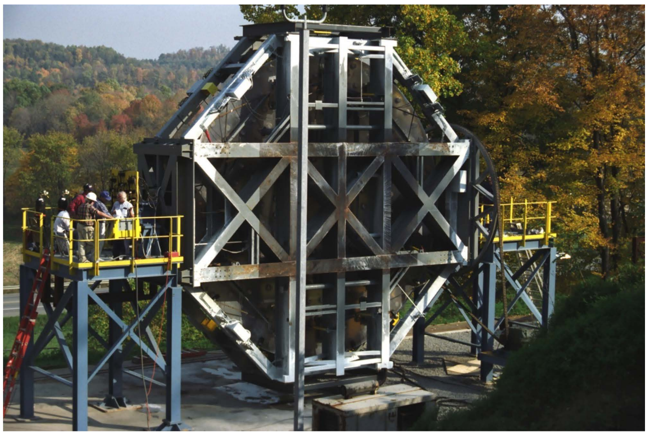
The mechanical structure of Subaru Telescope pre-assembled in the Sakurajima Dock was tested and was dis-assembled and was waiting the day of shipping. It was a day in September of 1996. The manufacturer invited a Kan-nushi and held a 'Shipping Ceremony.' Thus finished the domestic big works, and the main scene moved to the top of Mauna Kea where the assembling work will be done.

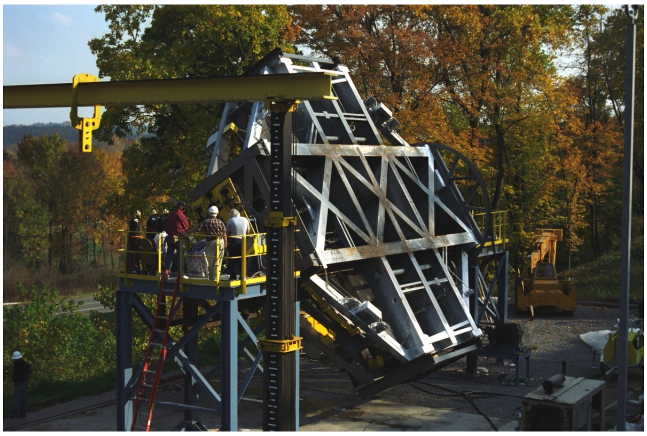
In November, the flipping of the main mirror took place. Since the mirror blank was manufactured in Corning and was transported to Pittsburgh, the eight-meter mirror was placed with its convex side up so that its rear-side be ground for holes. We were challenging the first experiment in the world to control the main mirror of Subaru Telescope with more than three hundred robot's arms in holes ground on the rear-side of the mirror. The work of grinding holes took more time than our first expectation. We were careful very much. As the work was over, we reversed the mirror so that its convex side is down and we could start the final grinding. For the Subaru Telescope main mirror whose thickness is only 20 centimeter while its diameter is 8 meter, the reversal of upside-down was a big work. After the reversal, it holds the concave-side-up position for its life-time long and will never be reversed.



Holes for the support points are dug in Wan Pan factory of Contraves.

Supoort arms to be used during the fabrication of mirror.





After the sag-down process in Canton factory of Corning, the concave surface of the mirror blank was facing down. In Contraves factory, holes for the support arms are dug on the convex side, then the mirror blank is reversed so that the concave side faces up.

After the successfull reversing process of the mirror blank that took one-full day, everybody is happy!

Grinding of the rear-side of the mirror was done in a factory built in an abandoned gallery of lime stone in the deep hilly areas. The mirror was pulled out from the gallery, was fixed to a wooden box, then was reversed, and was overturned which was two-day's work, and went back to the gallery where it came out from. Fortunately, the weather was good during these work. I presume that Prof. Nishimura might have felt something that might have shortened his life. The main mirror, after the grinding work of rear-side holes, was transparent and we could see three hundred holes with sockets made of super-invar. Each socket is cut into two and is fixed with silicone glue so that the effect of the difference in the rates of expansion become less.

'Will the control with robot arms with sensitivity of 10,000 succeed?'

I watched eagerly the rush of the film taken by Iwanami Films.

6.5

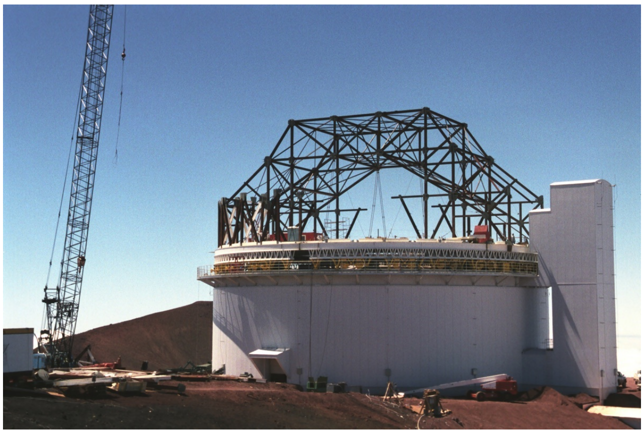
After the collapse of the bubble economy that flourished in the eightieth, statesmen, bureaucrats, and business people had to restart again because troubles of the Japanese society that expanded in the bubbled economy came to light. Arguments for re-establishing economy of Japan transformed ostensibly into arguments for re-establishing Japan, and administrative and financial reform became being discussed busily. But the progress of these discussions seemed to be near-sighted. They seemed to be safety measures for the time-being rather than a plan for one-hundred years span. Anyway, big sciences were criticized severely. Structural reform as well as promotion of science and engineering were discussed as tools for re-establishing the economy. But they were directed to the investments and economical stimuli that would soon reveal their effects. They could not be compared to the plan of promotion of science and engineering of Meiji era one hundred and thirty years ago. They seemed to become superficial easy toys. They were thinking of what would become useful to the society in five- or ten years. To astronomy, the truest basic science among the basic sciences, the supplementary budget were not allocated.

'What is it useful for?'

I reminded me of the question directed to me many times.

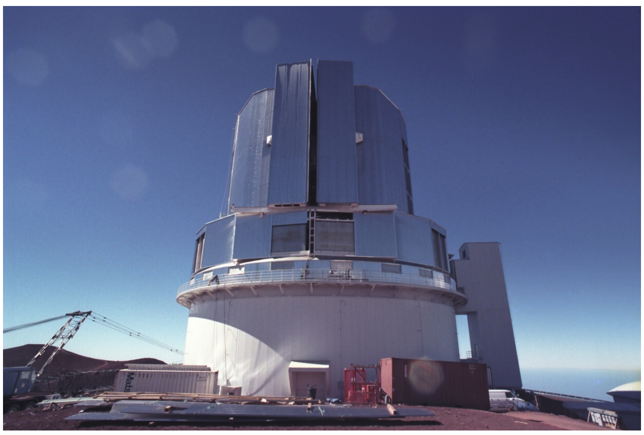
Construction of the telescope continued and the dome building on Mauna Kea showed its shining entire structure above the sea of clouds. The mechanical structure tested after provisional assembly was dis-assembled and was transported to Hawaii, and the assembly work on the top of mountain started.

The iron structure of the lower (fixed) part of the enclosure building with the concrete-pier of the telescope at its center.



The iron structure of the upper (moving) part of the enclosure building. The lower part and the elevator tower are now covered with white walls.

Observation building and the enclosure building. A little more work to be done with the latter.



The enclosure building is completed. The wall of the upper part is covered with Aluminium plate in order to avoid too much cooling at nighttime.

The large vacuum chamber that would be used to aluminize the eight meter main mirror was brought in and was being tested. It went up the mountain path slightly covered with snow in two days' trip. The construction of the base facility in the city of Hilo on the Big Island advanced rapidly. Developing and manufacturing of the observational instruments made steady progress. Members of Subaru Project team, both Hawaii and domestic staff, earnestly tackled the problems of the project. Both domestic and foreign researchers of astronomy are gradually considering the research projects after the completion. At first sight, it seemed to be progressing smoothly. But the near-sighted Japanese political situation made me feel uneasy. Subaru Project still held many long-time pending problems.

The vacuum chamber to be used for coating the Subaru Telescope 8 m mirror is carried up to the summit of Mauna Kea.

Already several hundreds million dollars worth national property was set up in the County of Hawaii of the State of Hawaii, the territory of the United States of America. So far, this project that started with the words

'There is no law to forbid it!'

was approved of its establishing national properties on the foreign land. The Board of Audit inspected the facilities several times and reported that no problem was found as far as the auditor's view was concerned. But the telescope is different from the war memorial monument. An organization to run the telescope has to be established on-site. In other words, a local organization of 'observatory' is necessary.

On the Antarctic continent, we have 'Showa Base Facility.' This is an obvious Japanese National scientific facility on a land which is not Japanese territory. In order to run the facility, an observational team or a wintering team is organized and is sent there. Running duty is carried by the staff on extended trips. As the Antarctic continent is not a territory of any country, running of the Showa facility can be made under the Japanese law as far as Antarctic Treaty is not violated.

Hawaii is different. Any facility set up there are bound by the laws of U.S.A. or by the laws of the State of Hawaii.

'Can we set up there an 'organization' which is a Japanese national research institute?'

It is a matter of course for a private corporation. But there is no precedent for a government facility. When seen from Hawaii side, this is apparently not an official organization of the State or of U.S.A. It is a private organization although it receives several benefits given to non-profit organizations based on a treaty between academic organizations.

This problem is not limited to astronomy only. Now that we often hear the word 'international contribution,' such a situation may take place in any field when a country is going to work cooperatively crossing the border. European and American countries have various half-private and half-governmental organizations that they have made grow up during their colonialism ages. These organizations behave officially for the internal matters but privately for external matters.

We have paid a lot of efforts in making surveys at the initial phase of promotion of the large telescope project, but we could not completely grasp the subtle difference. For Japan that has made a great failure at the last phase of colonialism, there was no accumulation of know-how in this field. It did not seem to me that the government would take care of this matter only for astronomers sake.

The dark cloud that stayed in my mind grew bigger and darker.

'It may happen that the facility will be completed without any infrastructure. Then we may have to repeat our predecessor's failure.'

One solution was that we entrust the telescope and the facility to the University of

Hawaii, and astronomers visit Hawaii one after another to make observations. With such a reluctant situation, we cannot expect fruitful results using the world's first-class instrument independently. Something must be wrong. Even for an observational instrument in Japan, if it is a small one and if it is located in an isolated area, it is understood that no 'observatory' is necessary and staff visit the instrument in turn.

'It may happen that such a situation be applied to our telescope in Hawaii. We may not hope a new system at one leap. Will it be possible to make it 'a facility of ministrial ordinance' based on the ordinance of the Ministry of Education and Research? Moreover, will it be possible to make it a 'facility with resident staff' that means the facility is the work place for the staff, and not the place where staff visit on trip-bases?'

It may be possible to have an organization on one spot and staff responsible for running the facility visit it in turn on trip-bases. However, there are many restrictions to foreign trips of a government employee. During long 'Foreign Trips,' as he is not at his regular work place, he cannot apply for research funds and cannot educate students. He cannot take his family with him of course.

Around the time when the construction work of the dome on the mountain top, my 'daily trip' to the central Tokyo started. I had to petition the government to solve these problems. The office of the Ministry of Education Culture and Science in charge of the National Astronomical Observatory of Japan, as might be expected of such an office, understood what we claimed. But the intention of an office in a ministry could not solve the problem at all as the problem was concerned of the organization of the state.

"As many offices are related with this issue, …"

The officer in charge could not give me a definite answer.

"To tackle the problem squarely may not be a good solution under the present situation, …"

He did not indicate what I should do. Logically, he might have said, ‘It is improper that a government employee is restricted by the local law when he is going to act with the governmental authority. ’

“Astronomers are not going to use administrative rights. There will be no substantial inconvenience while carrying out academic research activity.”

I refuted in vain because the arguments were changing to fruitless disputes.

“Then, can we introduce a new system to overcome our problem? …”

“I don’t think so. It will take a lot of time. …”

I could not find any hope although I had many consultations. And I thought that there was no way other than to send the budget requests without any prospects.

I decided;

‘I will send the budget request with the premise of the facility with resident staff where the observatory staff live and work there.’

The work for this budget request that included personnel matters was harder than I anticipated. To send the requests from the observatory from MESC to the Ministry of Finance, there must have been a lot of efforts by the parties concerned.

The matter was hard to deal with. When the summer was over, and when the request went out of MESC, it did not happen that we were in an awkward situation with apparent oppositions. We got a feeling that the organizations related with each other were going to say,

“I do not say please go ahead. But if you cannot find any other way to do it properly, we are not in a position to stop it.”

As the situation was very delicate, what I, the director, and staff of the Subaru Project team could do was to watch carefully holding our breath (crossing our fingers). Any activity like meeting people to deepen their understanding of our project or to appeal mass media might have brought us negative results.

We waited patiently although we were eager to do something. We believed that our activities in the past would flourish. We believed that the power of the project is big enough to overcome hurdles. At this time, too, somebody at some high-level, must have been working, I believe.

At the end of 1996, we got a good report at last. The cabinet's budget plan included establishing the Subaru Telescope, a new branch of NAOJ in Hawaii, as a facility with resident staff. It was an excellent organization that have three divisions for the use of the telescope, namely Telescope System, Observing Instruments System, and Observation of Celestial Bodies, plus Administrative Division. Together with making new divisions, divisions for research in the observatory were re-organized so that they can prepare to help Subaru Telescope in its development and to support it.

At the end of that year, The Japanese Embassy in Peru was occupied by an armed group. This reminded me of the complicatedness hidden behind 'establishing an organization abroad.'

6.6

As the prospects of establishing Subaru Telescope became sure, the matter of next great urgency was the selection of persons to be assigned to this facility. As the work on the site progressed, we have made plans of personnel to be sent to Hawaiii. However, as the number of people needed was small, we could manage by sending them on trip-bases.

In spite of poor conditions, Dr. Nariai and Mr. Nakagiri did their best devotedly. Now that constructions of all the buildings on site in Hawaii are finished and assembly and tune up of telescope on the top of mountain and start-up of the super-computer at the base facility started, we have to concentrate to select staff to be assigned to Hawaii. We have to make up friendship with local residents, and make up cooperative relationship with observatories from all over the world. Needless to say that these relations are based on staff with families rather than based on staff only without family.

We have paid a lot of efforts in construction, established the facility based on the ministerial ordinance, and one thing was not clear. It was the issue of allowance for assigning staff to Hawaii.

“Director, is the problem of allowance solved?”

Members of the Subaru Project team often asked me as the end of the fiscal year came close and we were looking for the new fiscal year when Subaru Telescope opens.

More than ten years ago when we were discussing the possibility of telescope project, when nationwide consensus among astronomers was heading toward ‘building a telescope abroad,’ response from researchers of the observatory was not good although they were the personnels most concerned with this matter.

How about the education of children? According to the general survey by the project at that time, there was a Japanese supplementary school in Honolulu, but not on the Big Island. On the Big Island, a school of high level that are comparable to the middle- and high schools in Japan was only Hawaiian Preparatory Academy in Waimea. Of course, English is used in the class. Later, I was told that the level of the middle schools and high schools in Hilo was by no means bad. According to the man who gave me this information, he had this idea because several children of researchers of Joint Astronomy Centre went to these schools. But how many staff would there be who can decide on their family matter of this sort? If their children are young and are at the lower age of elementary school, this problem may not have of much importance. So, for the young research associates, it is OK. For the senior researchers, the problem is a hard one.

If one’s spouse is going to live in Hawaii, another problem arises. That is his/her job. Most spouse of senior researchers, no matter if he/she is a man or a woman, do some kind activity in the society and get income. The Big Island is an isolated island of the U.S.A. and there is not so many jobs that suffice their motivation to work not to speak of the amount of income from these jobs. If he/she is lucky enough to find one, his/her job in Japan is cut and there is no assurance to continue the job after returning to Japan.

How about houses? I myself lived in foreign land several times and experienced many difficulties. It is rather easy to find a residence. But how about the house and furnitures in Japan? If he/she lives in a housing for government employee, the problem is bigger. As he/she is assigned officially to a facility in foreign land, he/she must leave the housing. Then, where can he/she store his furnitures? He/she has to leave his/her car in Japan because the steering wheel is on the right side of the car. If the move is within Japan, he/she can use his/her electric furnitures anywhere. But he/she cannot do that in Hawaii. Either he/she has to store them or dispose them. And he/she has to buy the new ones in the new location. He/she has to live a double life!

How about medical service? We can use the insurance of the Mutual-Aid Cooperative of the MESC. However, we have to pay at first, and are paid back later on. Medical system is completely different in Japan and in Hawaii. A simple medical care costs expensively. It is well known that dental care is very costly. Method of summing up hospital charges is different. It would be uneasy not to buy insurance in Hawaii. More so if children are within the family. People buy costly insurance for his/her car. In the society of U.S.A., it is natural to think 'Safety is bought by money.' So, it is natural to buy insurances, which costs a lot.

Inconveniences in the daily life is amplified by the barrier of language. Several staff started to go to English language school knowing that there is a possibility that they are assigned to the Hawaii facility. In this English language school, his/her diligence and earnestness became very well known. He/she may start with positive attitude, however, he/she may be confused in the beginning by the differences of customs, etc. There are television program in Japanese for limited hours. Japanese newspaper is also available. But these are exceptions. They may wish to have Japanese magazines. On the Big Island, there are only two movie theaters. Only American movies are shown there. In Hilo, the capitol of county, there is no theater that opens everyday.

No store is open after eight o'clock in the evening. Instead, activity starts early in the morning. People leave home to work at six o'clock. A family flight to Honolulu once a month would be a good distraction. Twice or three times a year, he/she may have to fly to Japan for ceremonial occasions such as a coming-of-age ceremony, a marriage ceremony or a funeral of relatives or for various meetings.

These items require additional expenses. In the survey report which we have made about ten years ago were included examples of foreign observatories. Detailed considerations other than the items written above were found in these reports. In order to use the first-class telescope built abroad, a system to send personnels worth for the work is built up. His/her basic salary is paid to his/her bank account in his home country, but the additional pay for his/her work on foreign land is paid there on dollar basis. The amount of additional pay is added up for many items, and is comparable to the basic salary.

The same report describes the examples of the additional salary for his/her work on foreign land of Japanese employee. Diplomats are special. Teachers of Japanese language school get appropriate additional salary for his/her work in foreign land. Teachers are either employee of local governments or government employee in a office related to MESC. Before they leave Japan, they are loaned to the Ministry of Foreign Affairs, and are assigned to the school abroad. The Office of Consulates of the Ministry of Foreign Affairs is in charge of this type of personal affairs. When it receives a request for help of this kind, it does necessary personal transfer, then send him/her out. According to a later survey report, it became clear that Japan International Cooperation Agency (JICA) receives non-regular employee and dispatches him/her abroad. JICA is a special subsidiary corporation of the Ministry of Foreign Affairs. It was also reported that many local governments have their office abroad and assign employees of local government recently. In these cases, additional salary comparable to that of the employees of government employees serving abroad is paid.

"Aren't researchers different? They are not requested to go abroad by its office.

They go abroad because they wish to. Isn't it?"

This question is interpreted as 'no additional salary is necessary.' Administrative officers and engineers who support the observatory are not considered at all. This way of thinking of 'they go abroad because they wish to' made the feelings of observatory staff uneasy. I, who serves as the director wishing to promote this project, and Professor Kaifu, who is determined to work as the first director of Subaru Telescope, almost felt that we were slapped on the face.

'We have spent such a big amount of budget to construct the telescope that you wished to have. You researchers do your best enduring hardships you may encounter. You don't say that you won't go Hawaii unless you get additional salary for going there?'

Such a voice comes from somewhere around me. This is the Japanese spiritualism.

Prof. Yasuo Fukui of the Nagoya University and Prof. Tetsuo Hasegawa of the University of Tokyo started southern sky survey with their small radio telescope. Prof. Yuzuru Yoshii of the University of Tokyo is planning to have a two-meter class telescope in Hawaii. I understand how they suffer from the hardships they encounter. Twenty years ago, we could not think of such plans. They are working hard to push their plans. When I think of the astronomical international center in the University Park of the Hilo city or the telescope domes of various countries on the mountain top or the international lodging facility at the level of two thousand eight hundred meters, I have got irritated and felt sad associating the Japanese researchers having financial difficulties and trying not to be known of the reason by astronomers of other countries.

It seemed that introducing the additional salary for assigning abroad was more difficult than establishing the Hawaii facility. Establishing Hawaii facility was done by the revision of the ordnance of the MESC. But introducing the additional salary for assigning abroad has to be done by the revision of the law that defines the salary of the Government employee.

All the MESC officers I met promised me to do their best. But it did not seem to me that there was a prospect for this. The revision of the law for the salary of the Government employee would not happen for the sake of only twenty people.

"Professor, it is by no means possible."

The officer in charge almost gave up to go further.

I declared bluntly,

"As the director of the observatory, I won't send any personnel to Hawaii unless there is prospect for this matter."

Officers concerned tried to manage to do their best and examined using flexibly existing additional salaries. Subaru Project team beat their brains to get out of the difficulties and summed up the prices that would be the basis of additional salaries.

If a station of the observatory is in a region of cold climate, additional salary of cold climate region is applied. But it is not cold at all in Hilo, Hawaii. It is warm. One may not spend much money on clothing.

If a station of the observatory is far from the station of public transportation, additional salary of a remote place is applied. This is not applied to Hilo as it has an international airport.

Additional salary for the metropolitan area or additional salary for the special area are applied if the living expense is costly because of the special location of the facility. As the State of Hawaii consists of islands far from the mainland, everything was more expensive than on the mainland. Cost of living in Hilo was higher than that of living in Honolulu, the capitol of the State. Nevertheless, costs of rice, meat, and residence are appreciably lower than those in Tokyo. Rental fee of a fairly large apartment is one thousand dollars.

"Professor Kodaira. Isn't there any other things to be added in summing up the cost? Your data show that it's easier to live in Hilo than in Tokyo. "

The officer in charge was compassionate with me. But the additional salary set by laws with domestic life expenses did not go up much.

‘If the facility opens with the present status, we will soon face a severe circumstance. I have to force staff to go to Hawaii with business order.’

Except for only a few professors and associated professors, I did not wish to ask staff to have the spirit of ‘special attack corps.’ With such management, competent staff won’t join us. If assigned to Hawaii, their morale would not be high. It is quite dubious if we could achieve the first-class results. It is certain that we feel ashamed among the international research center with burning hopes. If the final output of our efforts in twenty-years comes in this way, it was quite disappointing to me, to Uta, and to all the staff of the observatory.

“What is the difference from Nobeyama? Moving expense to Hawaii will be paid. I will sum up other additional salaries necessary that are allowed by the existing laws.”

And the study in the administrative division was over. I thought,

‘There is no other way. We have to endure with it.’

I got pessimistic thinking,

‘The key for this problem is ‘How much they can put on the Special Additional Salary.’ Later on, this will become sprout and then grow. The number of facilities abroad may increase little by little. Then, we may expect that the time when the ‘Additional Salary for Facilities Abroad’ is admitted. But, some people may say ‘If the additional salary is so low, going there on trip-basis is better.’ Then, assignment to the facility abroad may not increase. If things go that way, I am afraid that Japan continues ‘international contribution’ in the form of ‘contribute in the form of materials without human shape.’ ’

6.7

Then, an unexpected thing happened. Public opinion moved at a place unknown to us, and high-ranked people were working. At the last moment, the situation changed abruptly.

One day, the supervisor of the officer in charge told me unexpectedly,

“Professor Kodaira. I would recommend you that you visit the National Personnel Authority. Now, only the orthodox method is left for us.”

‘Does he mean that a system for international activities is necessary in order that Japan opens up the future full of vitality based on the ‘Fundamental Law for the Science and Engineering’? Is the additional salary for assignment abroad that Subaru Project is asking for is an example of it?’

Dr. Karoji and I visited the National Personnel Office immediately to talk with the high ranked officer.

The National Personnel Office is located in a provisional office building close to Iwaidabashi (Iwaida Bridge) that faces the Palace’s moat.

We entered at the front door with determined mind to speak frankly explaining the present status as we were told at MESC to negotiate with the ‘orthodox method.’

The man who met us in the executive office at quite a high level floor of the building was not a man with hardened face as often seen with an administrative officer but was a gentleman[2] with soft countenance. By seeing him, I remembered that he had a career of Professorship in the Science or Technology Department in a University.

‘Yes, I heard of him somewhere from somebody. He may understand us.’

Hardly we greeted and presented ourselves, I started to talk.

“Please prepare the groundwork so that staff of Hawaii Telescope can be active confidently and with dignity and pride.”

I explained desperately. The high ranked officer listened to me gently. It seemed to me that he knew our request beforehand. He said

“Yes, you are right.”

and continued

“We will study the matter so that we can respond to your request.”

After he asked us questions on several points, he also said,

"As it is an important matter, we have to do it properly."

He explained to us in detail as follows;

"In order to initiate Additional Salary for Assignment to Subaru Telescope, the law for the pay structure of the government employee should be revised. The proposal should be included in the yearly recommendation by the National Personnel Office, then submitted to the Diet. Time is limited, but the basic study will start, and a survey team will be sent to Hawaii."

I thought;

'The recommendation by the National Personnel Office is made in August, and the act is retro-activated to April. The payment will be made at the end of the year in the most favorable case. If those who will be assigned to Hawaii know for sure that they will get the payment at the year-end, they will be convinced. During the period from April to December, they may borrow money from, for example, the Foundation for the Promotion of Astronomy that was initiated for the purpose of some help in difficult cases. If this is realized, I will have accomplished the responsibility of the promotion of the project. Then, I can leave the project to the team completely.'

As if he read my thought, he said

"The matter may move slowly, but it should be done properly."

As the responsible person said this, I felt quite happy. Most of all, as I became to know that a high-ranked officer such as he has such an important post, I felt that the future of Japan is filled with glory.

One day in April, I visited the high-ranked officer in the National Personnel Office as I had an occasion to go to the metropolitan area of Tokyo.

'Hawaiii Station' had already been started. Director Kaifu and more than ten staff were assigned to work in Hawaii and joined Dr. Nariai and Mr. Nakagiri who were staying in Hawaii since long time and started to organize the system. Dr. Nariai was named as the Assistant Director on public relations, Dr. Tetsuro Nishimura as the

Assistant Director on Construction. Dr. Kazuhiro Sekiguchi was in charge of General Affairs, Dr. Ryusuke Ogasawara was in charge of Computer, Dr. Toshiyuki Sasaki was in charge of Control System. These professors and associate professors, young research associates and engineers, administrative officers of the first period, and staff employed locally, they were working hard. In the Base Facility, the super-computer started to work. On the top of Mauna Kea, the assembly work of the telescope was running in the dome that was shining blue-white reflecting the sky. The polishing work of the main mirror of eight meter diameter was already in its last phase. In the Subaru Project Office in Mitaka, Tokyo, business work connecting various locations increased rapidly. It was difficult to cover every aspect of the project with only the TV conference between Hawaii and Mitaka. So, experienced staff like Dr. Ando, Dr. Iye, and Mr. Takeshi Noguchi were working on very hard schedule. Japan was experiencing a sluggish economy. Preliminary stage of the budget request for Subaru Telescope for the next fiscal year has already begun. We have to be more careful on the budget request than in the past years as we are in the midst of the wave of the political and fiscal reform of Hashimoto Cabinet. We have to make up the details of the inside of the Subaru Analysis and Research building. Live images will be sent from Hawaii to this building. While the project room is chased by these works with the administrative officers, many young research associates and graduate students were busy developing and manufacturing observational instruments. Together with Subaru Telescope, Division of Optical and Infrared Astronomy and Observational System Research was initiated and Dr. Ando was named as the director of the division. He also became the president of the Committee of Research and Exchange, and Dr. Iye was named as the president of the Subaru Telescope Committee and Committee of Education in the graduate Course. The number of graduate students studying in NAO exceeded one hundred.

'If the problem of the additional salary for assignment to Hawaii is settled, the framework of the telescope project is almost completed, …'

With a certain anxiety in mind, I told the receptionist of the National Personnel

Office the purpose of my visit, and took the elevator to go up the floors. This time, I realized that the walls of his office were decorated with an artistic frame of painting that suggests highlands of Shinshuu in Autumn and an artistic photograph of children running lively in the field.

I hesitated to hear his answer to the question I made the last time I visited him, and I started to report the present status of Subaru Project.

“Thank you very much. Subaru Telescope was set up and its staff left for Hawaii and started their work.”

Then, I started to talk about what I wanted to know,

“Thank you very much for dispatching a survey team. My staff over there were very glad to see them as they made very thorough inspection.”

To my surprise, a very clear answer came back,

“It was good for you. I heard the result of the study team. We are still examining the final report. Perhaps, we may adjust the level of the additional salary close to that of diplomats. Of course, as this is recommendation, you must keep it secret before it officially comes out.”

I thanked him politely and left the building. Not being able to keep this good news only for me, I phoned to leading people. It is since long time that I walked through the government office quarter with such a high spirit. As usual, I dropped in the MESC and reported what I heard, then took a taxi to go to Roppongi suppressing my feelings that makes me almost whistle.

In the evening of that day, Uta’s retirement party was to be held in ‘Einhorn’, a German restaurant in Roppongi. Eventually, Uta taught at Tokyo Institute of Technology as a foreign professor for nineteen years. Students whom she helped when they were planning to go abroad and students who joined her seminar of free discussions organized the party of today. Uta put on a pleated body-suite of deep-green color and a flange on a red coat and wrapped a pleated shawl of the same color around her neck. Her originally chestnut hair changed its color to silver. She had made it a short crop.

After the toast of beer, followed Uta's 'Last Lecture.' It began with

"I wish to reflect on my personal history."

Then she began to make her speech in Japanese; life in Germany after the war and the life in the university where she met me, her trial to become a Japanese which failed, etc, etc. Her speech was scheduled to be a quarter of an hour, but it seemed that a half an hour was still too short. She decided to live as 'an excellent foreigner' rather than to live as 'a strange Japanese;' How she was related with the telescope project through me; She talked about 'Radio Japan' which is an international broadcast of NHK; Then she recollected the memory of students in Tokyo Institute of Technology.

Several years ago when there were activities to stop the contract of foreign teachers whose length of service was long, students carried on signature-collecting campaign by their own will. When she spoke of that campaign, Uta's eyes were filled with tears.

"Young people who gather here know personally that there are various civilization and various people. If the number of such people increases, Japan may be able to have many friends in the world. The road may be steep. In order to bring the campaign 'One Hundred thousand overseas students' to success, the supporting system and the hearts that support the system are important rather than shout or money. If this campaign continues in the present form, it may happen that ninety thousand foreign students out of one hundred thousand invited to Japan may return to their home countries with distrust and discontent with Japan and Japanese. Courses of foreign language in universities should be the window toward the admiration of and understanding different civilization rather than just the acquisition of foreign language for practical use. Astronomy leads to the understanding of humankind and the Earth while studying the universe. So, both are similar to each other."

While observing the faces of students and of Uta thinking this way, I reminded me of the words somebody said,

“To teach is to talk about hope together.”

Suddenly I thought,

‘Uta must have talked with students about hope wishing that it may be useful for them and that they may not sink in the Japanese society.’

It seemed to me that her talk was more than one hour long. After her talk, graduates gave speeches during the buffet. After that, young people went out to smaller parties after the main party.

Some people invited us with “Won’t you come with us?”

We declined the invitation and went out to the street. There, the spring storm that was increasing its strength since the evening was blowing hard.

Uta and I, we took seats in a taxi and began to think deeply of what happened today separately.

I tried to think

‘How would it be when I retire?’

But no image came out at all. The term of the director continues one more year. I didn’t know if the work as the director ends the next year or if I will be re-elected and continues to be the director. If re-elected, I will be the director for three more years. In the spring of 2000 AD which is three year later from now, the full-scale observation program of the Subaru Telescope starts.

‘It may be possible to promote international cooperative observation with the researchers of Asia-Pacific countries.’

Such thought revived what the high-ranked officer said this afternoon in the National Personnel Office. And suddenly to my surprise, I was filled with fresh feelings;

‘The additional salary for assignment to Hawaii will be realized! Young people will carry out the construction of the large telescope with pride. O.K. I will think about my observation!'

In the twenty-first century, Very Large Telescope (VLT) of the European Southern Observatory (ESO) on the southern hemisphere and Subaru Telescope on the northern hemisphere start their full-scale activity. Andromeda galaxy that I am analyzing with young people now lies two million three hundred thousand light-years away. The image being analyzed now is the image of two million three hundred thousand years ago. With Subaru Telescope, we can trace back to the ancient universe when we see as far as one billion light-years or ten billion light-years. It is similar to excavate ancient tombs and find out the roots of Yamato Imperial Court or solve the riddles of Paleozoic Era with the fossils dug out from deep strata. Astronomers 'excavate' the universe farther and farther in order to find out the origin of the world of materials. Keck telescope uses its enormous light-gathering power of ten-meter segmented mirror in spectroscopic observation of galaxies and quasars several billion light-years away.

'Can the Big Bang model explain all the observations?'

In ancient ages, human thought that they live at the center of the world. When the heliocentric system took over the geo-centric system, the solar system was the center of the world. In twentieth century, although we learned that the solar system lies near the edge of the Galaxy, we wanted to think that the Galaxy is the center of the world. But the Galaxy in which we live is one of galaxies floating in the expanding universe. We are, by no means, not at the center of the world.

Still, we are apt to think

'Lives are limited on the Earth.'

But it has no basis. Last year, it was reported that American scientists discovered something like the trace of life in the meteorite on the Mars. NASA, then, announced 'Project Origin' which aims at 'survey of the creation of the universe and the origin of life.' It is already known that many planetary systems exist other than the Solar system. Certainly, Subaru Telescope will start its search for 'the second and the third solar system.'

'Will the evidence of life be found on planets other than the Earth?'

Soon, we will be in the New Century when we trace back all the history of the universe and can grab the ranking of the Earth and Human-beings. At the same time, life and brain science will proceed to a stage where mechanism of life and structure of recognition of human-being are solved. Then, 'the universe inside' of human and 'the universe outside' of human are fused into one and we can expect a magnificent view of the world. Natural sciences are only a part of the mental activity of human.

'And then, all the people have a viewpoint of looking himself from the universe, get out of the self-central way of thinking, and put an end to the era where slaughter is repeated on this small Earth.'

While thinking these incoherent things in the car, we returned our house in Hamadayama.

We put the flowers donated at the party in a vase made by our eldest daughter, uncorked a wine bottle, and sat at the table for two. Outside, the spring storm was blowing as in the daytime.

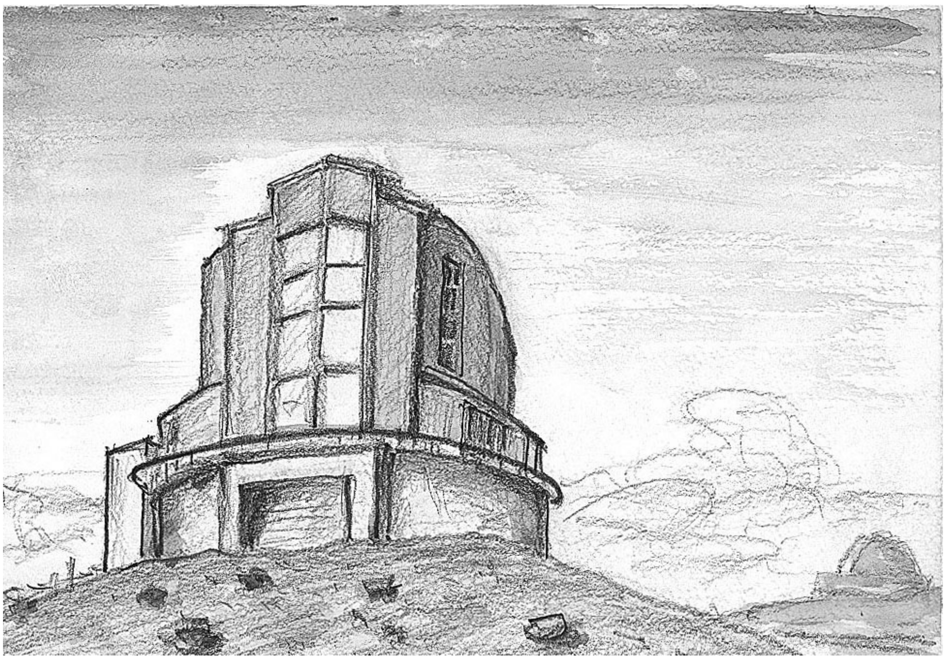
---

[2] Atsunobu Ichikawa

[Published] **Keiichi Kodaira/Kyoji Nariai**: **2016**, NAOJ-Books : Makali'i in Hawai'i.

Chapter 7

In the Storm of Reform



7.1

After her mandatory retirement from the Tokyo Institute of Technology, Uta got busier rather than having more free time. As she could make her schedule by her own will, she started to live with busier schedule; coaching of the fencing club of TIT, news gathering for Radio Japan as ever, volunteer activity for eye-handicapped students, etc, etc. She frequented to Hakushuu-Torihara where the kiln of our eldest daughter Monique stands in order to work together with her. She accompanied me to the ceremony of the completion of the mountain-foot building in June of 1997.

It rained that day in Hilo. The Hilo Bay which we could command from the balcony of the hotel was choppy. The thick rain cloud prevented us from getting a view of the Mauna Kea. If it were fine, the Mauna Kea with its large mountain skirt would have been shining lit by the rising sun beyond the Bay. The city of Hilo which lies to the East of Mauna Kea, a four thousand meter class mountain, was once a base of sugar industry. This fact tells that rain is quite common here. But it was raining hard that day and we were anxious if we can prepare safely the opening ceremony scheduled in the afternoon. We were told that a big tent would be pitched in the courtyard of the base facility.

"Oh! I see a lot of people on that small island. I wonder if there is a feast over there."

It was Uta who noticed it first. At the tip of this small peninsula on which several hotels are, there is a 'Park of Japanese Garden.' And we noticed several figures on the green turf of the island next to the Garden. They carried colorful clothes and chairs and tables. A stream of people came out of the cars parked close to the bridge, and the number of people increased instantly.

Polynesian music began. Then, big men and women started to dance cheerfully.

Uta could not stay quietly in the room, went out with a tape-recorder. It was a native Hawaiian feast praying for good harvest.

I was told that big rain is the good omen in Hawaii. It washes out dirt of the ground and gives vigor to everything. I understood why they danced cheerfully although it rained hard on the day of the feast.

The rain lessened once, but it began to rain hard in the afternoon. The University Park where the Base Facility of Subaru Telescope is located spreads in a corner of the Hilo Campus of the University of Hawaii. If we start from the shore of Hilo Bay, we cross the downtown Hilo and we reach there after a little bit of ascent of gentle slope. The main street in the park is adjoined by a large turf garden which is surrounded by buildings.

Our base facility was an elegant two-storied light-colored ferroconcrete building unique in this city of Hilo. It has glass walls on the side of the main street which is located beyond some green grassy area. On one side of the turf garden, young palm trees made a line. And a large tent that almost hides the low row of trees is pitched. Inside the building, the entrance hall was crowded with the reception staff who give leis to the guests, who prepare the video-filming, who prepare the foods and drinks that are served at the banquet after the ceremony. I noticed among them Professor Minoru Oda and his wife and Professor Kozai who came to Hilo for this occasion. I walked around in the building and peeked into the rooms that line up along the corridor. There were a few people in the offices and in the computer room, but in the laboratories and in the library, I saw only carton boxes that were piled up. While I was telling the prospect of the additional salary for assignment to Hawaii, staff of the University of Hawaii arrived from Honolulu. I looked for the director Don Hall in a hurry.


Subaru Base Facility building completed in the University Park in Hilo, Hawaii

About a month ago, I heard that he would be dismissed the directorship. He must have received the notice officially yesterday. This came up abruptly. It had its root in the political struggle among the islands in the State of Hawaii. it was reported that the president of the university decided after he received the proposal of the council. The director Hall did his best in order to develop the International Mauna Kea Observatory. And his role on the development of this University Park was large. The Island of Hawaii owes him very much, but the political group of other islands may have hated him.

As soon as he noticed Uta and me, he came close to us immediately and greeted us with his usual friendliness, then said

"I received the notice."

He told us that he is allowed to remain in the university as an ordinary professor for one year from now, and it was possible to sue as the dismissal was announced with a notice of such a short period. He also told us that he did not wish to do such a troublesome task. While we were talking, I noticed that he was quite tired. Uta did not wish to ask about his family either. The negotiation of construction of a telescope in Hawaii started at the time of the director Jefferies, the predecessor of Dr. Hall. But this Subaru Project saw this day after more than ten years of hard work with Director Hall. Nobody imagined that the dismissal is announced in such an unhappy form.

Professor Latimore, the president of the University of Hawaii, who announced him the dismissal appeared. Among many astronomer related to the International Astronomical Observatory, the President Latimore whose specialty is different from astronomy received lei with a little stiff expression. The University of Hawaii is run by the State. It is equivalent to a national university in Japan. Its council is composed of learned persons in the society like business executives and statesmen, and its decision is very powerful. In this case, even a president probably could not have resisted. The assistant director Dr. MaLaren and Dr. Tokunaga whom I can talk frankly were at a loss at the sudden news. But it seemed to me that they thought it unavoidable because of the influential power of the council.

The ceremony of the opening of the base facility of Subaru Telescope started while it was raining heavily. Hawaii style prayer for safety ‘chant’ was read by a sacred person first. Then, it was my turn to speak. I aimed to mention two things in the speech. One was to express the words of memorial to those who lost their lives in the fire of the Subaru Telescope Enclosure on top of the mountain and words of thanks to the Mauna Kea community for their solidarity which was shown at that time, too. Another was to thank Director Hall for his efforts during the long-time and to praise his achievements as a scientist.

Professor Kaifu, the director of Subaru Telescope, thanked the local society for its cooperation, then spoke with energy about what can be expected of Subaru Telescope. The master of ceremony was Dr. Karoji. He knew, as might be expected of a knowledgeable scholar, that heavy rain is a good omen and told of a Japanese proverb ‘Rain hardens the soil.’ Representing the Council of the National Astronomical Observatory of Japan, vice-chairman Professor Keiji Higuchi presented a token related to ‘Snow of Hawaii’ by Ukichiro Nakaya. It was related to the record when Professor Nakaya, famous for his research of snow, went up the Mauna Loa of this Big Island in order to get the purest snow crystal in the world.

After the formal speeches by Director Hall and President Latimore, Director Seiji Naya of the Office of the Commerce and Tourism representing the State of Hawaii stood on the podium. His talk was exceptional among many speeches given in the ceremony in that he spoke about the importance of scientific research while he also spoke the effects on the economical effects.

He spoke,

“We are striving for inviting high-tech industries in order to promote industries other than the tourism of the State of Hawaii, but science and engineering are based on academic research. Mauna Kea observatories is a property that the State of Hawaii can be proud of.”

Half of it might have been a compliment, but I thought that he has a great insight into matters. After his speech, I went to him to ask for shake-hands. He then gave me a name-card with his name printed with his degree ‘Dr. ’ According to Dr. Nariai, he has the doctor’s degree in the science-technology field.

When the party got into full swing, Professor Minoru Oda danced waltz with Uta under the tent. People with Japanese ancestral origin enjoyed Kara-Oke. They proposed to sing ‘Banzai Song.’ I could not what would happen and continued to watch them. Then, they shouted

“Banzai! Banzai! Banzai!”

which made me break into a cold sweat.

The next day, I visited the Subaru Telescope Enclosure on Mauna Kea. As the Consul General of Japan was going to have a reception party in the Consulate General of Honolulu in the evening, I could not spend much time on top of Mauna Kea. In the dome building with doors closed, I could see the giant telescope almost in its whole shape. On the observation floor, many parts were seen and bare cables for control were crawling around. In the control building next to the dome, new fixtures were set and the computer for remote-control of the telescope was set into operation.

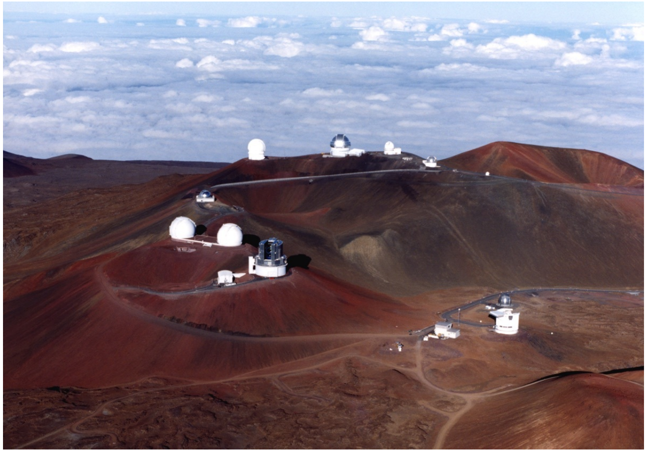
7.2

I could visit Subaru Telescope in March 1998, ten months after the opening ceremony. There was the election of the director of the observatory at the year-end. As the Subaru Project was in its climax stage, I was re-elected and I was going to continue to be the director.

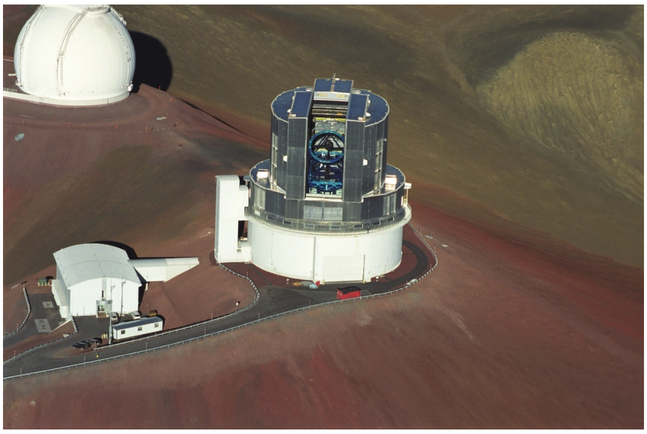
When seen from outside, the building and the turf garden of the base facility showed settled down appearance. Even the palm trees planted in geometrical patterns gave me an impression that they have been there for years. Because of El Ninõ phenomenon that affects the world's weather, the winter on the Big Island had abnormally long fine days. So, watering the turf was an extra work. From the veranda of the hotel we were staying, I could see the domes shining brilliantly reflecting the rising sun on top of Mauna Kea which is floating above the morning haze in light pink color.

View of Mauna Kea from Hilo. Domes are seen on the top.

The purpose of this trip was to have friendly talks with the staff in Hawaii as the director as one year had passed since the start of the station. TV conference system is used between the headquarter of the National Astronomical Observatory of Japan in Mitaka, Tokyo and Subaru Telescope. But it was difficult to use it in an atmosphere which may be called as 'friendly.' This year was the eighth year of the Project of Construction of Large Telescope, and the tenth year after the start of the National Astronomical Observatory of Japan. The target of the National Astronomical Observatory of Japan at its start was Construction of Large Optical and Infrared Telescope. As the plan began to take its shape, we were working out the second phase plan. That is to say, we will set the target of the research activity for the coming decade and we will change the organization and facilities. In November last year, the international committee was held so that the entire observatory is evaluated by members outside of the observatory, and the 'Fundamental Plan of the Second Phase Improvement Conception' was made while taking in the proposal written in the Third Party Evaluation Report. The purpose of this visit was to report the details of these activities and explain its content and to listen to their opinions.



Aerial view of the observatories on Mauna Kea in 1999. On the far ride of the ridge are (right to left), UH 24", UKIRT, UH88, Gemini, CFHT. Middle is IRTF, then Keck I and II, and at the front edge is Subaru. In the lower plain are (left to right), SMA, JCMT, and CSO.



Aerial view of Subaru Telescope Enclosure and the observation building during the construction time. To the East (left behind) is seen white Keck I dome.

As the number of the locally hired employees who do not understand Japanese increased, I had to prepare materials in Japanese as well as in English, which was a little bit troublesome. The staff who came from Japan could somehow respond to the daily work in English, but they wished to listen in Japanese from the Japanese director what are related with general matter and is not related with their specialty. I consulted with the director Dr. Kaifu and decided to do it in the following way; first, a meeting in English is held with all the staff, then another meeting will be held in Japanese; Also, it was announced that locally hired staff can stay in or leave the second meeting, and that those who wish to have a talk in English can come to the director individually.

The eye-catcher of the 'Fundamental Plan of the Second Phase Improvement Conception' is to construct an international super-large 'Radio Interferometer Array' in the desert plain of the northern Chile in South America at the height of five thousand meters. The Plan included discontinuing of or changing the purpose of old stations and big change of organization. In Japan, this type of matter is shown to all the staff and opinions are exchanged. But to the locally hired staff with different nationality, this was received as a little bit of surprise. For them, this kind of matter should be handled by the directors of the observatory and the station as the responsibility and the authority to make decision do not belong to them. It may have caused trouble to them to have a meeting for that purpose.

Staff from Japan wanted to talk about the work in Hawaii and about the conditions of life there. The recommendation of the National Personnel Office announced in August last year was approved in the Diet in December. The law of pay structure of government employee was revised. 'Additional Salary for Assignment to Hawaii' was initiated and was applied retroactive to April. The additional salary was determined to be 80 percent of the basic salary and adjustment system for the change in the exchange rate was introduced. But as the additional salaries of adjustment for working in city area and others vanished, the actual total salary do not allow a life very well off. As to the residence, a system was made that the Government rent it from the owner, then rent it out to staff. The decision was postponed by more than one year, which caused trouble to some staff who bought an apartment before the decision.

New staff joined one after another and the organization expanded. It was necessary to find a better way to adjust the system of bi-lingual instructions in Japanese and in English.

When I finished talking with Japanese staff and got out to the corridor, a locally hired staff came to talk with me. His talk was not only self-introduction but also a promotion of himself.

"I have been working in so and so company and did such and such work. I love Hawaii because it has volcanoes. Provided that the working conditions are satisfactory, I wish to work here for sometime."

He handed me pictures of volcano that he photographed and his work history, and added in Japanese,

"Dozo yoroshiku."

When he has gone, another locally hired staff appeared. Then, the third, ……. All of them seemed to be confident and skilled. They applied from all over the world having read the advertisement of the posts of Subaru through Research Corporation of the University of Hawaii (RCUH), and were selected among these applicants. I thought that Japanese staff who work everyday with these fellows may have hard time working with them.

Although there were several issues to be solved, the morale in Subaru Telescope seemed to be high. I thought that it is making a good start as an organization.

On the way back, I dropped in the Institute for Astronomy to make a courtesy visit as usual. To my surprise, I saw ex-director Dr. Hall who was dismissed. When my car went into the parking lot of the Institute, he was on the other side of the lot and was just getting in his car. I ran to him, shaked hands, and asked,

"How are you?"

He answered with his friendly voice,

"I'm fine, thank you. Subaru seems to be doing fine, isn't it?"

"Thank you very much. How is your family?"

"My son entered a university on the mainland. I plan to go to the mainland, too. See you again."

"See you again."

As he seemed to be in a hurry, we could not talk more than that. At the first look, he seemed to have good complexion. But it seemed to me that he is feeling lonely.

Soon after I returned to Tokyo, Dr. Nariai, who had been staying in Hawaii for six years self-sacrificingly, came back to Japan after his mandatory retirement. His work as an assistant director in charge of public relations was inherited by Dr. Tetsuro Nishimura and other young staff. But I thought that considerable efforts are necessary to keep the network of friends in the State of Hawaii that he made up during these six years. At his farewell lecture meeting in Hilo, he spoke with the title of 'My Three Cameras.' Over two hundreds people gathered together to listen to the talk, I heard. The first one of the three cameras is Subaru Telescope itself. The second is a special camera that he designed for the spectrograph of Subaru Telescope. The third is the X-ray telescope carried by a Japanese satellite for observation of the sun. It succeeded to obtain powerful dynamic images of the Sun that may completely change the image of gentle 'Sun the mother.' Dr. Nariai was energetic saying

"I can spend more time to make research."

although he complained

"In Tokyo, everything is small."

It was in August 1998, four months later, that I visited the base facility of Subaru Telescope for the third time. The inside of the building of the base facility seemed settled. Several teams have started the adjustment of observational instruments. Rooms that were empty when I saw them in Spring were filled with staff. The entire station was coming close to the state of perfect operation. The better-half of Professor Kaifu, Mrs. Shigemi Kaifu moved to Hawaii. She regretted that Uta was not traveling with me. Mrs. Shigemi Kaifu was teaching in Japan in a university, but she left her job this spring and came to Hawaii to stay with her husband. In the community of the Mauna Kea observatories, while doing her duty as the Director's Wife, she took care of the family of newly arrived staff, and even took good care of graduate students. For Prof. and Mrs. Kaifu who brought up four boys, taking care of students did not seem to be a matter to worry about.

When I said to Prof. Kaifu,

“You must be feeling at ease as your wife joined you.”

He answered in a little embarrassed way,

“Well, now I can really work.”

And he seemed to be very happy.

Saeko Hayashi who have spent three years in Hilo at the time of survey of the telescope project came back to Hilo with her husband Dr. Masahiko Hayashi and their children, and started a new life. Dr. Tetsuro Nishimura whom we asked to come to Japan and join our project used to live in U.S.A. He have had his wife come from Arizona and was getting back to American style life.

Inside the dome building on the mountain top, everything was put in order. Preparation for receiving the eight-meter main mirror which is expected to arrive soon was on-going. In the room which is used for preparation of observation as well as a lounge, I saw a TV set and a sofa. A small kitchen table in the corner of the room showed that human activity is performed there. In the control room, observatory staff and graduate students were working with corporate engineers scrutinizing the lined-up computer terminals. I was told that the adjustment work of the control function of the telescope had achieved its target.

This time also, I could spend only one day on top of the mountain to see the telescope. The rest of my stay in Hawaii, I had to meet the parties concerned in Honolulu and in Kona. Director Kaifu came with me. In Honolulu, my main task was to meet people in the University of Hawaii, in the State of Hawaii, and in the Consulate General of Japan in Honolulu. In the Institute of Astronomy of the University of Hawaii, I heard that the next director would soon be appointed. The parties concerned in the Consulate General and in the State of Hawaii were very glad to hear that the lengthy telescope project would be completed the next year. Specially, old-timer officers of the Union of the Society of Americans of the Japanese

Ancestral Origin wanted to have a big ceremony in order to make the friendship between the two countries firmer. Director Naya of the Office of Commerce and Tourism of the State of Hawaii phoned the Office of the Governor of the State to make an appointment with the Governor. Governor Caetano was busy. But I could have an appointment with the Lieutenant Governor Hirono. As Dr. Kaifu had a tight schedule and had to return to the Big Island, only I went to see her.

Inside the State Building, there were many beautiful wooden doors decorated with engravings of Hawaiian natural feature. Lieutenant Governor Hirono is a woman of the Japanese ancestral origin. She appeared with blue loose dress on her slender body. When I was going to admire her dress, she spoke,

"You have a wonderful neck-tie with stars on it!"

"Thank you very much. Your dress is very nice. I thank you very much for your time while you must be very busy."

Conversation was held in English. Director Naya, sensing that the Assistant Governor is busy, started to talk,

"As the completion of the Japanese telescope is close, I brought the Director of the National Astronomical Observatory of Japan so that he greets you."

"Telescope, is it?"

It did not seem that Assistant Governor knew Subaru Telescope well. So, I started to explain briefly the development up to that time and thanked the State of Hawaii for its understanding and cooperation. As the dismissal of Director Hall happened quite recently, I told her about the schedule of coming events cautiously not to mention about the political situation over the Mauna Kea observatories. Lieutnant Governor Hirono said,

"So, it's the next year that the telescope is completed. I envy you the astronomers because you can foretell what happens the next year."

Smiling, she winked at Director Naya. Director Naya explained,

"There will be election November this year. A strong rival opponent against the present Governor appeared. If he takes the chair of the Governor, all of us will lose the present post."

On the last day, I headed by car from Hilo to Kona which is on the opposite side of the Big Island, and went to the assembly hall where an international conference on astronomy was held. It was not to attend the conference that I went there. I aimed to have a tripartite consultation with Director Giacconi of the European Southern Observatory, Director Vanden Bout of the National Radio Astronomical Observatory, and myself. The subject of the consultation was the huge 'Radio Interferometer Array' planned to be constructed in the desert plateau at the height of five thousand meters in the northern Chile, South America.

Preliminary negotiations have already been started during the General Assembly of the International Astronomical Union held in Kyoto last summer.

In the General Assembly of Kyoto, young Japanese researchers were very active. Presentations by Japanese in the astronomy and in related field gave strong impact to the participant of the Assembly from various countries. In such atmosphere, negotiation of international collaboration about the Japanese big project that follows Subaru Project developed. Japan made the survey of Chilean plateau and concluded that it is the best site for observation of sub-millimeter radio-wave of wavelength of less than one millimeter. The area is undeveloped desert. In order to construct an observatory, it is necessary to develop the land and improve the infrastructure. Since last year, Japan and U.S.A. started collaboration of detailed survey of the candidate site. Recently, European team asked American team to start a plan of collaborative construction. Eventually, the time came for Japan, U.S., and Europe to join together to make the concept of 'International Collaborative Radio Interferometer Array.' If Japan could make a team with Asian countries and make the collaboration with Europe, U.S., and Asia as members, it would have been better. But we thought that it was premature.

Several radio astronomers from Japan, U.S., and Europe joined the discussion over dinner in Kona in a friendly atmosphere. However, we had to be very careful about the negotiations behind the scene. For Japan, as this was to be the first international collaboration, we needed to response properly at the international level which was far higher than in the case of Subaru Project. In my brain, the scene of heated debate about 'construction abroad' twenty years ago revived.

"I do not hope that the same thing happens. As far as the economic situation allows, the scientific society as well as the Government will treat it positively."

I decided to think this way and left the Big Island by an early flight the next day.

7.3

The polishing work of the eight-meter main mirror of Subaru Telescope was a little behind the schedule. According to the plan at the time when the mirror blank arrived at the polishing company in Pittsburgh, it should have been completed by March, 1998. Already half a year was passing by.

In March, the last process of polishing with the finest abrasive was going on but the polishing was becoming harder because of the thickness of the mirror of only twenty centimeter and because of two hundred and sixty one holes on the rear surface for the robot arms that support the mirror. Near the hole of one meter diameter at the center of the mirror and at the periphery of 8.3 meter diameter, it was difficult to polish because the mirror bended when the polishing work was forced. It was anticipated that the same kind of phenomenon appears in the region between the support points of robot arms. When the polishing progressed further, the opposite phenomena occurred; It was harder to polish the part just above the support point rather than the area between.

In order to avoid direct contact of the head of robot arm and glass, there is a gap between the two. It was probably caused because the thickness of that part was only five centimeter while the thickness of the other area was twenty centimeter. Consequently, the pattern of unevenness caused by the part that were not well polished was fine and it spread all over the mirror.

Dr. Ando and Dr. Iye who were in charge of the main mirror said,

“It may be the time to finish the work. But I wish to continue a little bit more so that our mirror has a better quality.”

I encouraged them saying,

“You are right. To make a good mirror is more important than to make it quick. Once it is finished and moved to the top of Mauna Kea, it will remain as it is for more than half a century. It is almost impossible to correct it.”

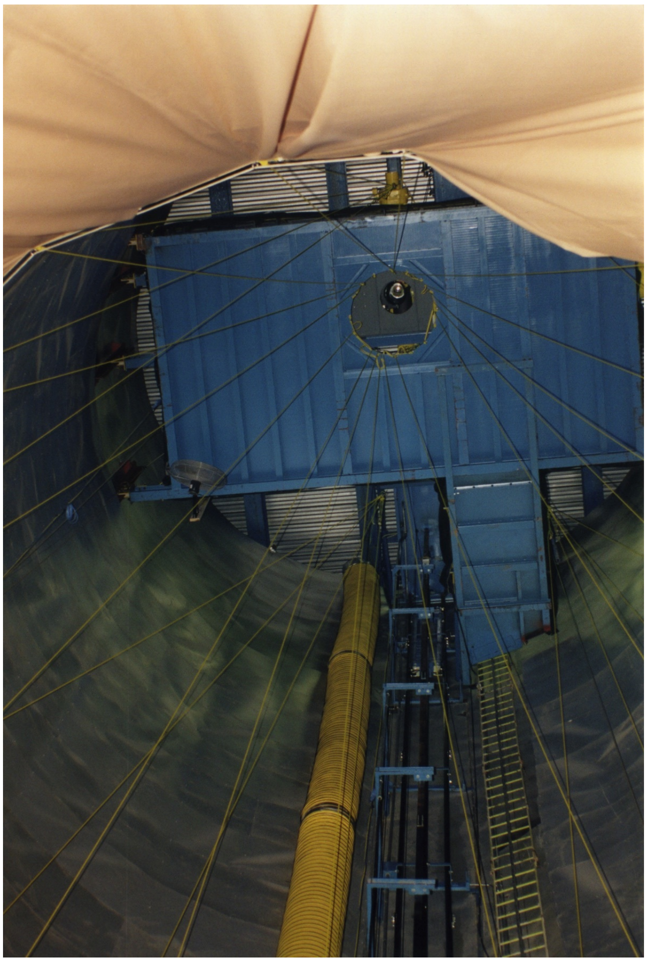
And I said the same thing to the staff of the company.

Back into the factory of Contraves in the old limestone mine.

Shieth machine is used to polish the mirror.

The deadline of March passed. Then one month, two months, …. On top of Mauna Kea, the assembly work of mechanical structure was completed and the test of the control system was making progress. The polishing work of the main mirror was almost a psychological warfare. At the site of the polishing factory in Pittsburgh, a young engineer from the Mitsubishi Electric Corporation, the main contractor, and a young engineer from Subaru Telescope of NAOJ, were staying for an extended period. We made preparations so that an engineer from the Mitaka campus, NAOJ, go there to support them on duty in turn.

Around the end of July when we were going to make the judgement of stopping the polishing work, Dr. Wataru Tanaka who were holding on for several weeks got out of condition a little after Dr. Ando took his place and was hospitalized because of stomach ulcer when he dropped in Subaru Telescope. When the mirror is still on the polishing machine of the factory, the mirror surface is tested with laser light. Based on its result, theoretical calculations of the expected stellar image is made. Then, the final judgement of stopping the polishing work is made. If small unevenness remains, although the starlight gather together sharply around the center of the focus, a very weak halo remains in the extended area around the center. When the Subaru Telescope searches the Second Earth, that means a planet around a fixed sun-like star in short distance, if there is a halo around the image of the bright fixed star that corresponds to the Sun, it is impossible to observe a faint planet that is expected to be there. It was because of this that we had to be very careful in making the decision making measurements and calculations over and over again. The polishing factory was made in a deep abandoned gallery of a limestone mine so that the stabilization of air is assured. But a small disturbance of the air in the measuring light-path which is sixty meter long will be annoying. It was necessary to separate the component of fluctuations making measurements many times. At the last phase of polishing, polishing was made even with the human hands directly. But I admire the expert of polishing. They knew the vital points of polishing at the final stage at the level higher than what we amateur worry about, and the



Inside of the thirty-meter vertical tower seen from above.

hand-work of the last phase went smoothly than expected.

After we received the finished mirror, we put it on the genuine support system with robot arms and made the surface test. For this test, Dr. Iye went to Pittsburgh from Subaru Project Office in Mitaka. As the supporting power can be changed actively on the genuine support system, it was expected that a better result can be obtained than on the polishing machine. But our expectation was based on the engineering experiment performed ten years ago with a one-meter mirror and on the theoretical prediction, it would be too much if we say that we did not worry at all.

After I returned from Hawaii in the beginning of August and when the work in Tokyo for the budget request for the next fiscal year came to the end of the first stage, I took a late vacation in the end of August and visited the southern Europe with Uta. According to the original schedule, the mirror must have been shipped to Hawaii after having completed all the tests before my summer vacation. Actually, I had to worry about during my trip. Mrs. Masuyama whom I asked to look after the director's room during my absence will send me FAX report to everywhere we go.

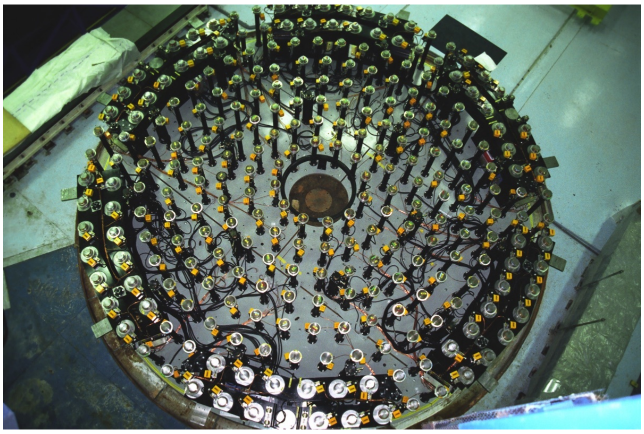
The main purpose of this summer vacation trip was to visit friends and relatives of Uta to whom she had not met for a long time. I wanted to have a good rest. The itinerary was a very busy one; fly to Sicily via Rome; Stay at the house of the director of Catania Astronomical Observatory for a few days; Go to Nice via Rome; Take a rent-a-car and visit Uta's sister and her husband in Provence; Return to Tokyo. The entire trip was scheduled in ten days. Everybody I met in Europe told me, "It was hot this summer."

The couple, my sister-in-law and her husband, both of whom are painters, moved to their favorite Provence and lived an easy life after they had retired from the professorship of Gymnasium. Their house was an old big farmer's house re-built atelier-like and commanded a splendid view. From the veranda in the yard where I liked to sit and relax because dry wind blew gently there, huge hill of Mont Ventoux shined white reflecting the Sun beyond the fields of herbs and vineyards.

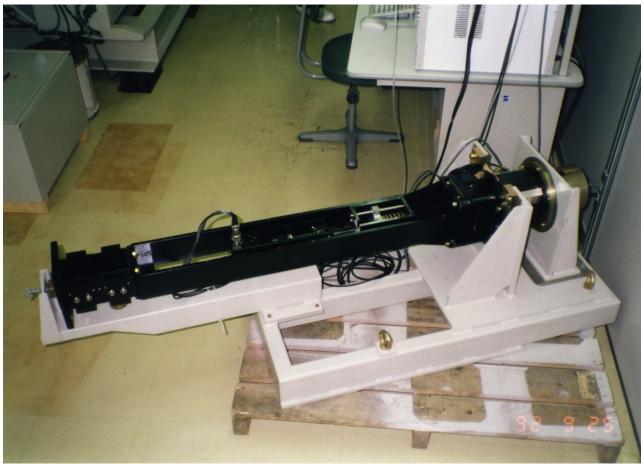
When I was recalling the night in Syracuse, Sicily, the songs I heard in the open-air theater by the eye-handicapped tenor singer Andreà Bocelli, the small harbor town of Côte d'Azur, the deep-blue colored warm Mediterranean Sea at Saint Rafaël where I swam, the calmness at noon with water and green which I met at L'Isle-sur-la-Sorgue, I received a FAX from Mrs. Masuyama in Tokyo. It was the forwarding of the press release of August 28th.

"Polishing of the eight-meter main mirror finished and the mirror achieved the world No.1 performance when it is supported by the active support mechanism. Remaining unevenness is 12 nanometer on the average."

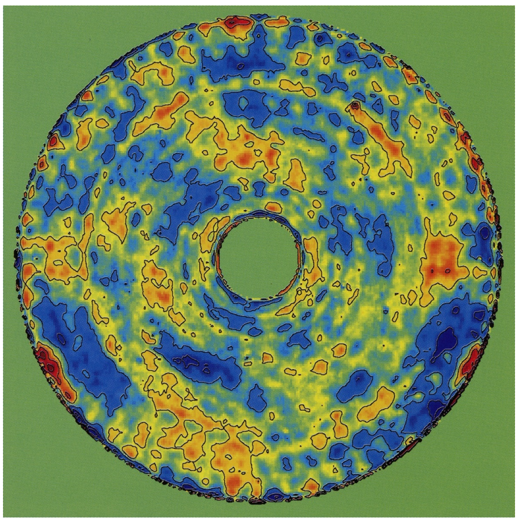
One nanometer is one millionth of one millimeter. If the eight-meter mirror is enlarged to the extent as big as the Kanto Plain, the unevenness is one tenth of millimeter. This accuracy of mirror surface was better than that of any other large mirror in the world ever publicized. The image recently announced taken with VLT1



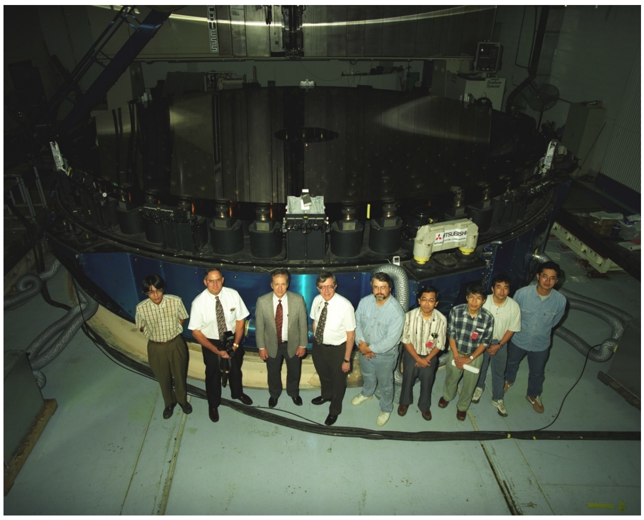
Mirror cell with 261 actuators.



Actuator.



R.M.S surface error of the polished 8.3 m mirror is 12 nm.



Polishing is completed!

telescope of the European Southern Observatory (ESO) showed galaxies fainter than those taken by the Hubble Space Telescope. If we use the compensating optics with the Subaru Telescope mirror, we will be able to do quite a job.

“We have done it! It was worth while to wait for the finest mirror!”

I shouted unconsciously. Uta, her sister, and her husband, all three shouted for joy. The actuator with the sensitivity of ten thousand that we have developed was worth our pains. The final test of the mirror with the real support system showed that the rigidity of the Subaru Telescope thin mirror is fairly low than expected. This fact may be understood as the effect of many holes dug on the rear side and furnished very useful data for the actual use of the telescope.

When I returned to Tokyo in September, I found harsh realities of administrative reform and of fiscal structural reform. The economic conditions of Japan were getting worse and there was no sign of recovery from depression that covered Asian countries.

In the budget for this fiscal year of Heisei 10 (1998 AD), the operating costs of observing stations were cut by 15 percent across the board. We were told that we can not expect that these decreased costs be recovered in the next fiscal year. If we spend the operating costs on a simple object like a refrigerator, it is possible to cut down the fee for electricity by fifteen percent by stopping the operation of the object. But our case is quite different because we will be operating the world’s first class telescope. Surely a certain amount of the operating costs is spent as the fee for electricity. But the world’s first class level is maintained because we continue to introduce the newest technology and improve the telescope. As it is an apparatus used by the researchers in the universities of all over Japan, if we spend the budget for operation of the telescope as expected by the observers, we will not be able to spend money for development. As a consequence, we may drop out from the frontier of astronomy. Then, the number of the users will decrease because the world’s first class results do not come out. And the recovery from such a downward spiral will not be easy. In other words, the refrigerator does not operate and the foods inside go bad. We may throw away our possessions that we have built up during these long years of hardships not being able to use it effectively.

A situation inconsistent and hard to be understood was formed while the fundamental law for science and engineering was enacted and the fundamental plan was established and special budget is carried out for the promotion of science and engineering in this financial difficulties. Besides, an issue of transferring the national research institutes to independent administrative corporations came up. National institutes of Japan in the field of basic science were formed as inter-university research institutes by the universities like the National Astronomical Observatory of Japan in the period of economical growth of 1970s to 1980s. They are now in the flower season and are expecting fruit as the carrier of science and civilization. It seemed to me an extreme opinion to sort them out together with other administrative systems in order to improve the efficiency and service.

Certainly, becoming independent of the stiff system of the nation, we will get more flexibility in carrying out budget or in employment. And in the academic field where activities of projects extend across the borders like astronomy, an organization that gets support from the nation but is not the nation itself can do things with more flexibility. But such changes to new organizations should take place with sufficient measure when the national finance is in good condition. We cannot accept changes that are made quickly for the sake of economy. Anybody would be anxious about it. It is almost the same as replanting trees that have just begun to grow in the cool season without fertilizer. However, at the age of change that Japan is facing, it may have been important to face it with hope.

One of our hopes lied in the fact that Professor Rojin Arima, a physicist and ex-President of the University of Tokyo, assumed the Minister of Education. At the election of the Upper House in July, Democratic Party fought well unexpectedly. As a consequence, Hashimoto Cabinet resigned and Obuchi Cabinet took its place. This brought the birth of Minister Arima. Professor Arima had experiences as the chairman of council of many inter-university research institutes including the

National Astronomical Observatory of Japan.

'Japan is changing. There are many people who are striving to make it better.' I told to myself.

Political environment of the world was changing rapidly. It started with the Blair Government in UK. Jospin Socialist Government in France was followed by the election in Germany in September which ended with the victory of Social-Democratic Party. As the consequence, change of government from Kohl Administration that succeeded in unifying the Germany to Coalition Government of Democratic Party and the Green Party occurred. It is reported that the people of Germany are embarrassed by the big change. In May, India and Pakistan performed experimental atomic bomb explosion to the disappointment of the world. But in our neighboring country Korea, Kim Dae Jung became the President. This opened a new door to the Japan-Korea relation that aims at the future. In November, visit of Jiang Ze-min, the Chairman of the Republic of China, is scheduled. I felt a new tide is coming in Asia, too.

7.4

On the 17th September, the eight-meter Subaru Telescope mirror was carried out of the polishing factory. It was securely packed and was put into an octagonal wooden box and was put onto a river boat of the Ohio river. The boat sailed from Pittsburgh, Pennsylvania, went down the Ohio river, and entered into the Mississippi river. It was held up at Memphis, Tennessee because Hurricane George that attacked the whole coast of Caribbean Sea was supposed to change its course to the north. So all the ships that were sailing near the mouth of Mississippi were prevented from sailing.

In the director's room of NAOJ, Mitaka, Mrs. Masuyama and I were worrying everyday. Looking the pink flowers of angel's trumpet in the yard, we talked,

"Was it possible that they could set sail?"

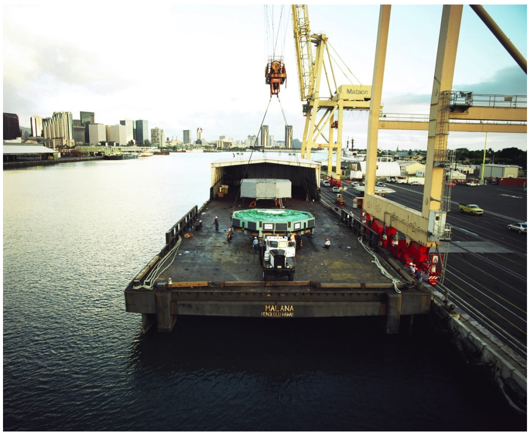
Route of transport of mirror from Pittsburgh, Pennsylvania to Hawaii through Panama Canal.


Final cleaning before putting the mirror into the shipping container.

The side close-up view of the shipping container with wishes of the people worked for the mirror.

The polished mirror is stored in a crate and leave the Contraves factory for Mauna Kea, Hawaii.


Through the highway to the port of the Ohio river.


Arrived at New Orleans.

In the mean time, Professor Kaifu reported that there had been no direct damage by the hurricane. He also reported that the river boat arrived safely at New Orleans, terminal of the Misissippi, and that the mirror was transshipped to an ocean cargo boat 'Moque Puff.' According to Dr. Karoji, the manager of Subaru Project Room, there had been discussions on whether the mirror be stowed in the hold or be held on the upper deck for the safety's sake. Finally, it was decided that the mirror be stowed in the hold. The cargo boat passed the Panama Canal in the middle of October.

It did not take much time before the main mirror to arrive at the mountain top. At Subaru Telescope, Director Kaifu and all other staff were ready for the work after the arrival. At the Development and Experimenting Center of Mitaka, NAOJ, experiments of mirror washing and aluminizing had been repeated many times. More than ten staff who were in charge of these experiments went to Hawaii, and made rehearsal with the genuine vacuum tank on top of the Mauna Kea.

"After cleaning, how do you wipe the mirror?"

I asked the staff who came back from the rehearsal. Automatic cleaning apparatus is, roughly speaking, car cleaning machine made flat. Even in the case of car-cleaning, we often see the final wiping is done by human hands. Before the mirror of a reflecting telescope is put into the vacuum tank, it would be natural to wipe the mirror with well-washed out dry cotton clothes with squeaking sounds.

"The last wiping depends on human hands. About eight people will get on the surface of the mirror."

They answered as if nothing worried them. It may be nothing to worry about thinking of my experience at the Corning Company when I got on the surface of the molded mirror to make inspection. I worried about if they might be paralyzed because the mirror surface they were going to get on a surface with unevenness less than twelve nano-meter.

"Be careful about safety! The air is thin on the mountain top. Something may go wrong with someone while working hard. Prepare for the case when someone faints."

I told them unnecessary words. When the mirror was cleaned later, several staff were compelled to get on the mirror to remove the adhesive of the protecting film on the mirror surface. I also heard that the adhesive tape that was put surrounding the mirror at its periphery in order to prevent leak of the cleaning liquid lost its adhesive strength because of low temperature, consequently the working staff had trouble of leak of the cleaning liquid.

The cargo boat Moque Puff in the Pacific Ocean safely arrived at the Honolulu Port on the second of November although it changed its route a little bit in order to avoid the Hurricane Lester and it had a small trouble with its engine. At Honolulu Port, the mirror was transshipped to a river boat again as the port of Kawaihae was shallow. Two large wooden cases of the main mirror and of its active support stood side by side on the pier of the port of Honolulu. The wooden case of the mirror was put on the load-carrying platform of a truck, then transshipped to a river boat. These events were made to images on the internet every moment by the staff in charge of public relations of Subaru Telescope and was sent to Japan.

Around the time I was looking at these images in the director's room in Mitaka, Uta was in Hawaii.

As soon as she knew that I could not leave Japan because of my work, she insisted

"At least, I will go there. I wish to cover the events for Radio Japan."

Probably she wanted to see the completed to fully-fledged eight-meter mirror although there was another motive of voluntary coverage of the events for Radio Japan. As the decision was made in a hurry, I worried a little bit. But her visit was realized partly because Aiko Michelle who was taking a training course in the hospital of Johns Hopkins University agreed to accompany her in Hawaii and partly because Mrs. Kaifu was very glad to see her and sent her a message "Be sure to come!"

The main mirror of Subaru Telescope arrived at the Subaru Telescope Enclosure on top of the mountain at three thirty five in the afternoon of November the fifth, 1998 Hawaii time. Immedeiately electronic mail from Director Kaifu arrived, then a telephone call to the director's room followed. According to Subaru Telescope, the transport operation started early in the morning of the fifth as the boat entered the port of Kawaihae on the fourth. A trailer with six axles equipped with hydraulic adjusting mechanism started toward Mauna Kea with an extra trailer providing for a case of a breakdown.

On the way, fuel of the trailer ran out. When the trailer was supplied with fuel from the accompanying trailer, a subtle difference of fuel caused a problem and it caused a two-hour's delay.

The results of the general election of U.S. was reported on this day. The Democratic Party fought well and it was decided that the present Governor of the State of Hawaii, the Governor Cayetano, to keep his post. I felt relieved to know that the political situation in Hawaii would be stable for time being and to hear at the same time the safe arrival of the main mirror at the mountain top.

Arrived at the port of Kawaihae, Hawaii.

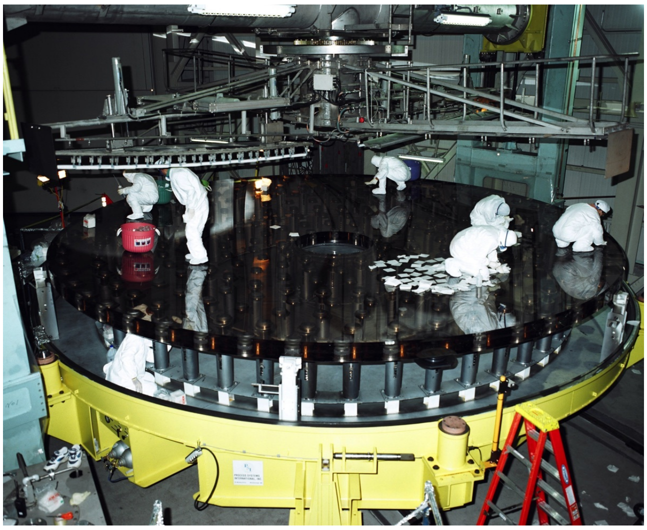
The 8 m mirror is carried up to the summit of Mauna Kea.

Uta on her return from Hawaii told with excitement how it went with the aluminizing of the main mirror of Subaru Telescope. It was fine that day on the mountain top, but thin cloud appeared from somewhere from time to time and snowflakes were dancing in the sunlight. In the lower part of the dome, people in parka and with mask were working. When the aluminizing started, all the people were watching eagerly the monitoring TV that showed the inside of the vacuum chamber. Soon, a signal of the completion of aluminizing was shown and the gigantic upper cover of the vacuum chamber was opened and the glittering eight-meter main mirror appeared. All the people watched the test operation holding their breath thinking

The Subaru-mirror is transported through the Saddle Road.

'How was the result?'

After careful testing, it was found that the result was not one hundred percent OK but was found to be moderately good for the first aluminized thin film on this size of mirror. It was decided to make the test observation with this mirror scheduled about one month later. On this memorable day of aluminizing of Subaru Telescope main mirror, Dr. Chiaki Mukai who made the second flight on Space Shuttle returned to the earth with the astronaut Glenn, the senator.



The film that protected the mirror during the transportation is removed.

"Finished thin meniscus mirror looked very elegantly."

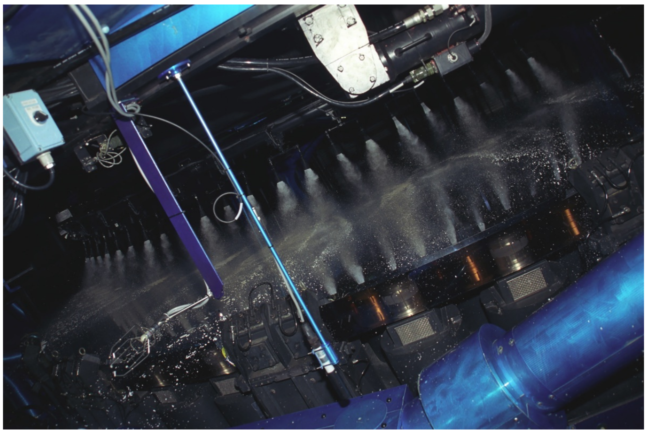
Uta satisfactorily told me. Then she added worrying about the health of Director Kaifu.

"Dr. Kaifu and all the staff are doing quite well. But what I am worrying is that Dr.

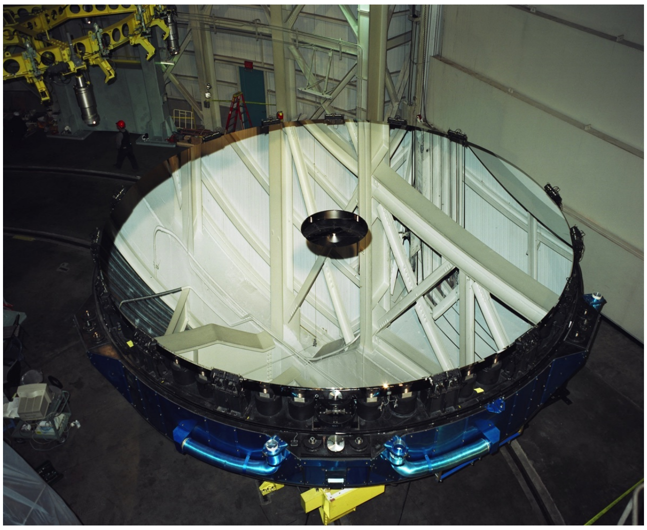
Kaifu may overwork. As Mrs. Kaifu is in Hilo, I hope such a situation does not occur."

The schedule of work in Hawaii was so pressed that made her worry that way. To tell the truth, in the evening of the day before aluminizing, one of the 4WD vehicle coming down the mountain overdrove the road shoulder and fell on the slope, and four members belonging to the team Subaru were injured. Immediately, Director Kaifu sent me the news. In Hawaii, preparations were made that sufficient medical care be available. Fortunately, it did not end with a serious matter. But this accident was a good lesson for the work on the mountain top after this.

Uta brought back other fresh reports from Hawaii.



Then the mirror is cleaned by the machine.



The Subaru Telescope main mirror as it came out of the aluminizing tank.

Dr. Hall, who was abruptly dismissed last year the post of the director of the Institute for Astronomy, the University of Hawaii, made up his mind not to move to the mainland but to do research and development in the Hilo branch of the Institute for Astronomy which will be newly established. And the candidate for the next director who was supposed to sign soon resigned to do so because a condition he asked was not fulfilled. So the selection process had to go back temporarily. She also heard about the visiting professorship system of the University of Hawaii. Similar to NAOJ, the Institute for Astronomy of the University of Hawaii has positions for guest professors and it would receive guests not only at the headquarter in Manoa but also at the Hilo Branch on the Big Island from the year next. Hearing this, I decided to know the details of this system so that it might profit me in case of observation on the Mauna Kea.

While the eight-meter main mirror is cleaned and aluminized, the support system of the main mirror was carried up to the mountain top, and the assembly work of the telescope became full-scale. Actuators were tested and were assembled into the support system one after another. As the number of actuator was quite large, the work was estimated to take almost ten days.

In these days, fabrication of observational instruments to be used in the test observation were on a spurt toward the end. Our most concern was on the secondary mirror. Starlight that enters the eight-meter convex main mirror is reflected and is gathered at the top part of the telescope tube that is fifteen meter from the main mirror. If we put a convex secondary mirror instead of putting a camera there, starlight heads toward the main mirror again, goes through a hole at the center of the main mirror, and focuses at the rear-side of the support structure that supports the main mirror. As this position is at the bottom part and not at the top of the tube, a large observational instrument can be installed. So, it is easy to work there. The first test observation was scheduled to be done at this position, but the vital secondary mirror had not arrived at Hawaii yet.

The appearance of Leonids heated up all the Japan in the middle of November. Around that time, instruments to be used in the test observations were sent out for Hawaii after having been tested in the Development and Experiment Center in Mitaka. In Pittsburgh the polishing of the secondary mirror was advanced at a fast pace, and the fabrication of the mechanical parts for the secondary mirror was at the last stage in Japan.

Fabrications of the real instruments to be used in the open use after the test observation were in their climax. Dr. Iye was in charge of Faint Object Camera And Spectrograph (FOCAS) to be used for spectrography of the most faint celestial objects. Dr. Tamura was in charge of Coronagraphic Imager with Adaptive Optics

(CIAO) which is a stellar ‘coronagraph’ to be used in the survey of the primitive planetary system. Dr. Yamashita was in charge of Cooled Mid-Infrared Camera and Spectrograph (COMICS) that catches radiation from cosmic dust. Dr. Ando was in charge of High Dispersion Spectrograph (HDS) with resolution of more than 10,000. Each led his own team and was working for the last finish.

Infrared Camera and Spectrograph (IRCS) for the observations of infrared objects and the main parts of special device for observations fainter objects were close to their completion by the work of the team led by Dr. Tokunaga of the University of Hawaii and Dr. Maihara of the University of Kyoto. The team led by Dr. Okamura of the University of Tokyo worked on the wide field camera for the survey of primitive galaxy and had already made the world’s largest detector. But the development and fabrication of the huge camera lens system to be used near the top of the telescope tube has just passed a hurdle. It is a four-lens optical system and the diameter of the largest meniscus lens is sixty-centimeter. It was a very difficult system to fabricate. However, thanks to the great effort of the engineering team of Canon, it was beginning to take shape.

In late December, the secondary mirror and its support system were transported by air to Hawaii, and all the parts of the telescope were there. And adjustments of the optical axis and mirror surface started. Engineers of Mitsubishi Electric Corporation headed by Mr. Osamu Sakakibara and staff of NAOJ in charge of the work got vigorous thinking

‘Now, it is the time we work!’

I wished to go to Hawaii very much, but it was not easy to leave Japan as I was the director of NAOJ. The depression of Japanese economy was said to have passed its bottom. But the number of companies that went bankruptcy per month and the unemployment rate were rising. We could not predict what would occur with the third supplementary budget and the budget request for the fiscal year 1999. Early in November, the Chuo Koron Publisher was swallowed up by Yomiuri News Co. Early in December, Iwanami Film Co. Ltd. filed for personal bankruptcy. Several ex-employees continued the work of record-imaging of Subaru Project. It was hard to see that a company that was doing conscientious business could not manage although it was the current of the time. I felt helpless because we could not do anything while having received many helps from them. Fiscal reform was shelved in order to make the recovery of economy to have the priority. With the administrative reform, the importance of making the system slim and efficient was emphasized as if to compensate the shelving of the Fiscal Reform. At the time when the Soviet Union and the U.S. launched the structures of the Space Station and made them successfully docked together, universities and related research institutes were in a situation that they have to make their own reforms. I was trying to resist with all my might to the shortsighted way of thinking. If Japan acts as they insist, it will lose the intellectual property that Japan, after the war, worked hard to build. On the other hand, movements of Europe and U.S. on the international project 'Large Radio Interferometer Array' which NAOJ plans to construct in Chile became active, and it was necessary how Japan side responds in the Japan-U.S.-Europe tripartite conference that would be held early next year.

While the international society was shaken by the attack on Iraq by U.S. and UK, and domestically all the nation became speechless when they knew of the coalition agreement of the Liberal-Democratic Party and the Liberal Party, the initial optical adjustment of the Subaru Telescope that started on the Christmas Eve went well after the team got the knack of it although there were several trials and errors at the initial phase. After the unofficial announcement of the budget bill for the next fiscal year by the cabinet, there was not so much work for me in the director's room. Everyday, I went to Subaru Project Office and watched the live images of Relay from the Mountaintop of Mauna Kea sent from Subaru Telescope. Stellar image on the monitoring screen in the observation room in the control building on top of the mountain was sent to the Base Facility in the city of Hilo through the optical fiber cable, then was forwarded to the monitoring room in the Subaru Telescope Analysis and Research Building in Mitaka, Tokyo through the TV conference system. The engineering team of Subaru Project Telescope patiently took in data with different star position and different focal position during the engineering experimental observation in order to have better overall performance of the telescope. Those who were related with the project on the mountaintop and at the Base Facility in Hawaii and Mitaka in Tokyo, all were watching the stellar image on the screen. It was extended at first, but became smaller and smaller day by day. I joined the staff of Subaru Project Office to see the image. It was the time that I could forget daily affairs concerned with the administrative and fiscal reform as the director.

Near the midnight of December the thirtieth, 1998 local time, Japanese Large Optical and Infrared Telescope Subaru received for the first time the stellar image, the target of the engineering experiment, on the top of Mauna Kea at 4,200 meter above the sea-level. Temperature at the site was 1 centigrade, wind was 5 meter per second which was a little strong, the weather was fine, and the airflow was ordinary. It was the midnight of the thirtieth, but it was five o'clock in the afternoon of the New Year's Eve in Japan. Ordinary employees of NAOJ, Mitaka were taking the year-end's vacation. However, project members in Tokyo including me were watching the TV screen in the TV conference room of the Subaru Analysis and Research Building. If the altitude of the star observed is low, the position of the main mirror is slanted which makes the adjustment complex. So, a star with the altitude between eighty and seventy degrees was selected. Changing the position of the secondary mirror little by little, forces on the robotic arms of active support were adjusted. For a moment delicate adjustment continued, then the stellar image at the center of the screen converged to a sharp light point.

Someone said,

"Whao! It's sharp now!"

then, the whole room was buzzing with excitement.

Even on the top of Mauna Kea, a small amount of fluctuation of air exists. Stellar image analysis system was about to start and it was expected that the evaluation would take sometime. So the relay from the top of Mauna Kea was stopped for a time. Later, director Kaifu reported that the stellar image was as small as 0.5 arc second.

‘Adjustment of the telescope is progressing well. Within one or two weeks, necessary data will be acquired, and astronomical image will be taken tentatively. Then, take time in the adjustment. Soon, we can observe!’

“Now, we can enter the New Year with ease of mind.”

“That’s it, certainly. Happy New Year!”

When I got out of the building after saying good-bye, it was already dark in Tokyo while I didn’t notice of it. It was very cold that evening of the New Year’s Eve. The moon was nearly full. It was shining bright above the blackish trees of Musashino. Looking hard at the night sky, stars of Orion were seen in the Eastern sky. As if leading them, the six stars of the constellation Pleiades (Subaru) were shining together high above the sky.

7.5

In the New Year, test acquiring of astronomical images started from the night of January 4. Subaru staff in Tokyo including retired Dr. Nariai and spouses of staff got together in my small house in Suginami to celebrate this in the New Year’s party. On the tenth January, test acquired image of Andromeda galaxy was immediately brought back from Hawaii. There were countless faint stars that I had never seen before. Stars with one hundred millionth brightness of the sixth magnitude star that could be recognized with the naked eye filled densely the screen. I felt as if I were looking countless eggs of fish that filled the vast sea. Dr. Satoshi Miyazaki who made the detector took the image. He was joined by other researchers in the discussions.

“Fantastic! This supersedes the Hubble Space Telescope's image in the accuracy of photometry.”

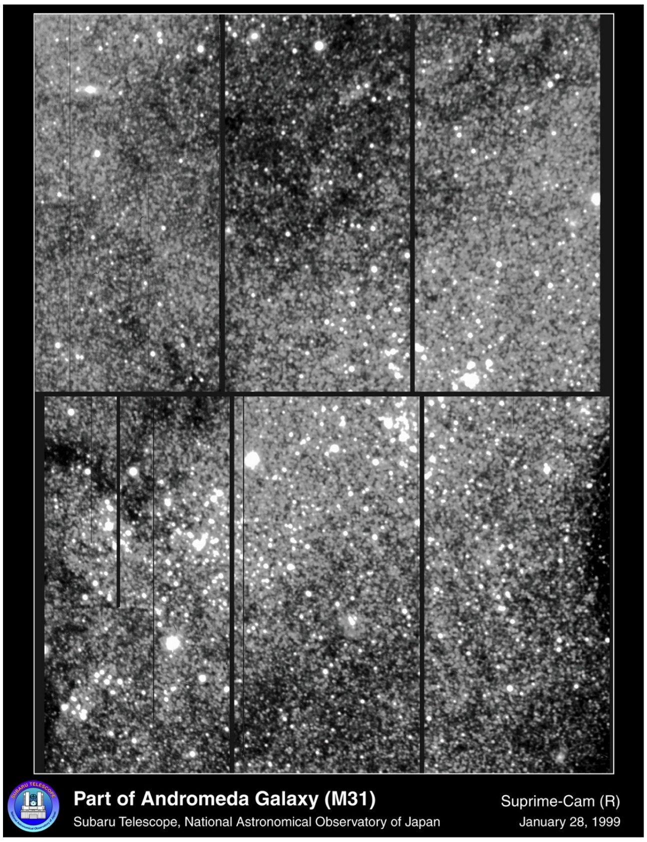
“Can you forward data from Hawaii?”

"I have brought it in a tape so that we can evaluate it. Shall I put the data in a computer?"

"O.K. Let's check how faint we can measure."

"It takes time. I have plenty of work before I go back to Hawaii the day after tomorrow."

Everybody was buoyant, but he had his own work to do and had no time to make analysis steadily.



Test image of Andromeda galaxy.

Then, Dr. Iye came back from Hawaii. In the Subaru Project Office of Mitaka, Dr. Karoji, Dr. Ando joined the discussions on the brought-back image of distant group of galaxies.

"A galaxy that is not seen on the Hubble image is there!"

"It must be a dusty galaxy with big redshift."

"You may be correct. Hoorah!"

Unconsciously, we cheered. But these three staff had their own work to do and could not afford to do the analysis. Among them, Dr. Karoji, the head of the Subaru Project Office, was busy responding the press. It was not allowed to publicize the test image before the press conference at the end of the month. But he received many inquiries already.

In the end of January, the president of Japan Academy Prof. Yoshio Fujita visited Mauna Kea. Uta and I were his guides at the test observation on Mauna Kea. Somehow, she could get on very well with him, so Uta took the role of his secretary and caretaker. Uta was glad to see friends in Hawaii, but was more so being with Professor Fujita.

Professor Fujita gave advice as an astronomer to the translator of a book ‘Glass Giant of Palomar’ which I had read as a boy. He was in charge of most difficult researches and negotiations abroad at the time of construction of 188-centimeter telescope at Okayama which was completed in 1960. I attended his class in the graduate course of the University of Tokyo. Later, I took the doctor’s degree in science when he was the head of the Department of Astronomy. During this large telescope project, he often encouraged me. He was waiting its completion more than anybody else. He was selected as the Mesiudo [1] at the Utakai Hajime [2] of this year coincidentally and composed a Tanka [3] as

‘Aozorano Hoshio Kiwamuto Mauna Kea Ugoki Somenishi Subaru Tataemu.’ [4]

Thus, it was quite natural that I accompany him to Mauna Kea.

At Subaru Telescope which I visited after half a year interval, staff were busy with the test observation, analysis of the observational results, and preparation of press-release of the ‘First Light’ which would come soon. Two years had passed since the establishment of Subaru Telescope.

Administrative officers some of whom belong to the second generation, researchers and engineers whose shift is three years in principle, and locally hired staff, all of them were working busily. Professor Fujita was ninety years old, but he was more energetic than we were, and he was very glad to see active Station. In the directors room of the Station, he broke into a smile being surrounded by his old students and Director Kaifu.

On hearing the good news,

“We got a champion data of stellar image diameter of 0.2 second-of-arc.”

he responded

“I have almost gave up to observe because of my age. But hearing such a good news, I would like to become an observing astronomer again.”

When handed the ‘First Light Image,’ he looked at it with bright eyes.

Professor Fujita seemed not suffering from time-difference on the mountain-top, too. Energetically, he visited not only Subaru Telescope but also other large telescopes. When he met Subaru Telescope, he was touched and shook hands with the staff on-site.

The next day, I was with him on the mountaintop during the observation time. That night, the weather condition was rather severe; Wind-speed was 10 meter per second and the temperature was four degrees below zero. When we got out on the 'Cat's Walk' that surrounds the upper part of the dome, it seemed that the blowing air would freeze instantly. As we were accustomed to the darkness of night, the half-moon was glaring. Air-flow was a little bit unstable. From the sea of clouds extended all over, mushroom like clouds were raising their heads here and there. In the western sky at a low altitude, Venus was glittering. Jupiter stayed in the middle of the sky, and Saturn was seen at the shoulder of the half-moon. Towards the east of the moon near the zenith, bright stars like Rigel and Betelgeuse of Orion, Pollux of Gemini, and then Sirius decorated the night sky. In the South-East sky barely above the sea of clouds, Canopus, the brightest star of the constellation Draco, was rising. It was the moment when we feel the rotation of the Earth.

Two round-roofs of the Keck telescope were shining white under the moonlight. On the ridge beyond them, moon-lit dome of the Canada-France-Hawaii telescope and other domes were also recognized. Wind direction seemed not fixed. While going around the cat's walk, wind came right from the front several times. Although Mr. Nakagiri who knew the circumstances well was guiding, I became to worry little by little. Finally, Uta ordered as the care-taker to stop the walk on the cat's walk and we went down using elevator. In the preparation-room of the control building, we took off the parka with naming of Subaru, and had a cup of tea. Then, we moved to the observation room on the other side of the corridor.

In the observation room, three people including an engineer of MELCO were at the control desk of the telescope, and five or six people were at the control desk of observational instruments. The latter group consisted of research associates of the

Kyoto University and the University of Tokyo, and graduate students. There were many computers that produce heat, but not only because of the heat source, the room was hot and stiffing. Probably, so many people were working together because the work-flow was not automated in a system. Before the telescope is used as an inter-university research institute, the telescope should be operated by one person and the observational instrument should be operated by one or two persons.

Professor Fujita came close to the control desk of the computer, peeked into the monitoring screen, and read figures and numbers on it enthusiastically. Then, he wanted to know what would be the necessary exposure time to get a spectrogram of a faint carbon-anomaly star that he wanted to observe once but could not afford to do it because the star was too faint. When a young staff answered that he cannot estimate how much time it would take because his specialty is galaxies and he did not know about stars, he said,

"Study astronomy with a wider scope."

A staff explained,

"Tonight, the airflow is a little rough. As the stellar diameter does not go down below one second of arc, let us wait a little more."

I thought,

'If we were observing with the old telescope, we would have started observation,'

and recognized that a new era began. Soon, the disorder of the airflow became small and observations of distant group of galaxies started, and exposures of fifteen to twenty minutes were repeated.

Professor Fujita watched closely the monitor screen and would not leave it. Uta, as the care-taker, ordered to stop it, and the two went down the mountain a little after ten o'clock. I remained there to watch the test observation. Although we had a champion's record once, many works are left before the effective observations are done. And sometimes peculiar data that are hard to understand appeared when watched closely. It is important to catch such subtle extraordinary signals and analyze and understand them. After watching the working scenes, I also went down the mountain after midnight. It rained at the sea-level.

The next day, it was Sunday. We went for a drive to the other side of the island to see the base facilities of Keck Observatory and Canada France Hawaii Telescope observatory. In Waimea where refined office buildings of these observatories are, the sunlight coming through the clouds and the misty rain made a beautiful rainbow. When we passed the town, we were driving on a road through the lava plateau of the North Kohala. That was the road Subaru Telescope main mirror passed. We drove further toward Kona City, then stopped at a hill that commands a beautiful scenery.

As we got off the car, warm wind of the island covered us. The sunshine was dry and strong. Air was transparent. The coastline drawn in white curve beyond the vast lava slope separated the dark-blue sea and the black lava land. Around the place where the curve is blurred, the foot of grand Mauna Kea started and the ridge went on above the clouds. Sound of waves did not reach us. We stood side by side with hairs blown by wind and saw the horizon.

Professor Fujita was looking at the cloud that hangs over Mauna Kea and said to us who were standing next to him,

"You have worked hard for a long time, and you have done it well!"

"Thank you very much. But the real work starts now. We may say that the present status may be compared to a baby just born healthy. In order to make it an authentic telescope, there are a lot of works to be done."

"I agree with you. I hope you do it with the energy of all the staff."

The wind passed by while we three were gazing a cloud at a far distance.

'Not only the technical side of the telescope, but also the operation of Subaru Telescope which was established abroad for the first time and the lives assigned to Hawaii. Now starts the real work!'

I was glad to know the results of 'First Light,' at the same time I reminded me of the importance of the duty that all the staff are facing at. The duty of not only the staff of Subaru Telescope but also of all the staff including those at Mitaka who supports in Japan and come here in turn by assignment.

Wind blew and shells of a vegetable resembling field peas made noise. Relatively short Professor Fujita straightened his back and stood firm on his two legs and gazed the ground.

"Shall we go back now? We have to do packing for the return flight of tomorrow. I have to prepare also for the press release in Japan."

I called his attention to our return trip and we got on the car.

That evening, we were invited to a dinner at director Kaifu's residence. Dr. and Mrs. Wataru Tanaka joined us. Dr. Tanaka was working hard in the telescope project. When we returned to the hotel, I found a FAX from Tokyo. It reported the schedule of the conference among Japan, U.S., and Europe on the 'Large Radio Interferometer Array' to be held in February, and the news of administrative reform that the transition to independent administrative corporation was accelerated. I recalled the firm expression of Minister Arima, Minister of Education and Science, who concurrently hold the post of the Director of Science Technology Agency on January 14 when the coalition cabinet of the Liberal Democratic Party and the Liberal Party was formed.

The next day, I dropped in at the Institute for Astronomy of the University of Hawaii in Honolulu. The news of 'First Light' was already known in the Institute. Female secretaries who helped me for a long time during the promotion of the project came to see me jumping and said to me

"Congratulations!"

The response of the University of Hawaii and the community of Mauna Kea observatories was that they thought that Subaru Telescope would carry it through but was surprised to know of so smooth a start-up.

That night, Dr. Don Hall, ex-director of IfA who lives on the Big Island and is doing research and development called me on the phone of the hotel.

“I heard the news of your First Light. Congratulations!”

Secretaries of IfA might have him informed. I was moved to tears.

January 29, 1999 (28th Hawaii time), the day to announce the first astronomical images that Subaru Telescope acquired came. It was simultaneous announcement with Hawaii and Japan connected by TV line. The press interview room of the Ministry of Education, Science, and Culture was overcrowded.

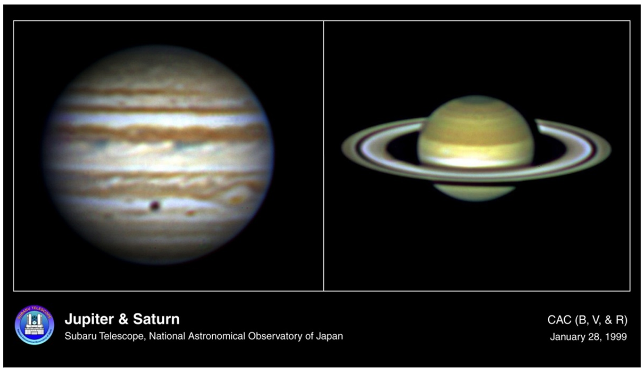
“Congratulations!”

Dr. Bob McLaren, the acting director of IfA, the University of Hawaii, held out his hands to me in the TV screen as if he wished to shake hands with me. In the TV screen, it was the conference room of the Subaru Base Facility in Hilo, Hawaii. Here, it was the press interview room of the Ministry of Education, Science, and Culture in Toranomon, Tokyo.

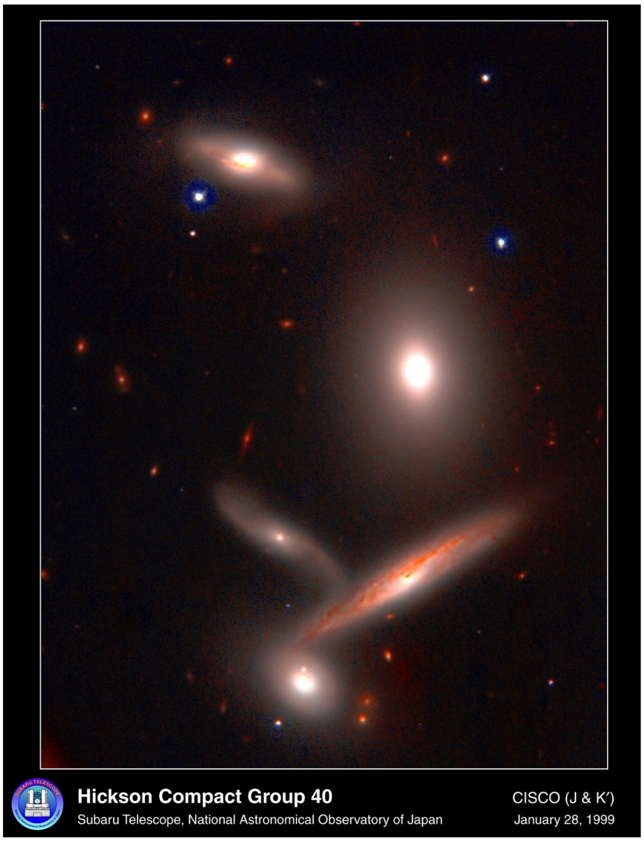
A short speech by the MESC explaining the academic background was followed by the description by NAOJ of the aim, specifications, progress of construction of the telescope. Then, came the views of the ‘First Light’ by the Subaru Telescope;

‘Engineering first light started on December 24, 1998 and Astronomical first light with test observation camera started on January 4, this year. We could obtain magnificent pictures of various celestial objects by the day before yesterday although the weather on the mountaintop was a little changeable. Subaru Telescope could produce image size of 0.2 arc second at near infrared radiation In the images of a cluster of galaxies at five billion light-years away, with one third of the exposure time of Hubble Space Telescope, fairer objects are detected. The near-infrared image of the central part of Orion nebula, the other side of the dark nebula an faint and extended structure that could not have been seen with the Hubble Space Telescope are recognized. These results show that Subaru Telescope has the top-level performance among the large telescopes in the world. Better performance of the telescope can be expected after more measurement and quantitative analysis of the primary mirror and the dome configuration. I believe that we will achieve big results after such improvements and with the authentic observational instruments instead of the test observational cameras. ’

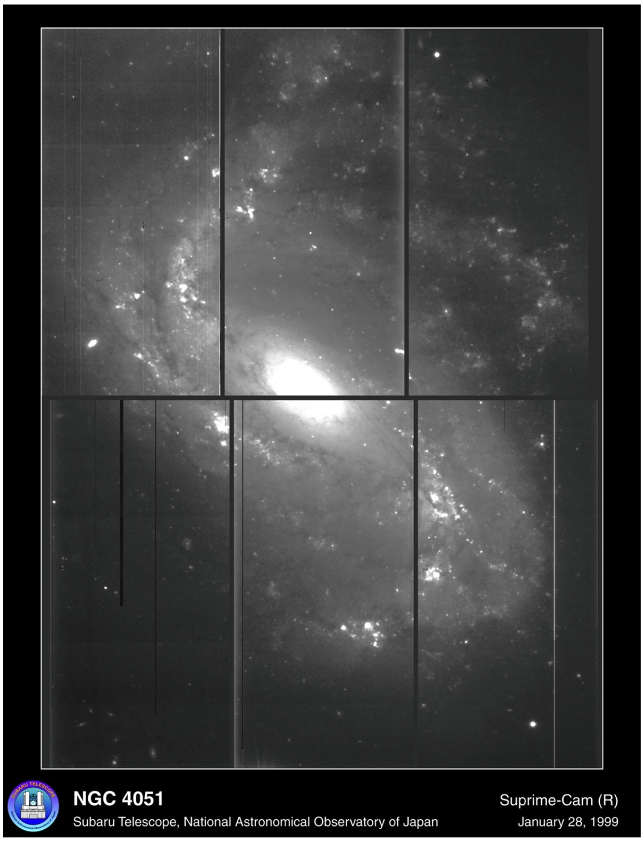
In the observaing room, everybody is looking at the first light image on a computer screen. ©NAOJ



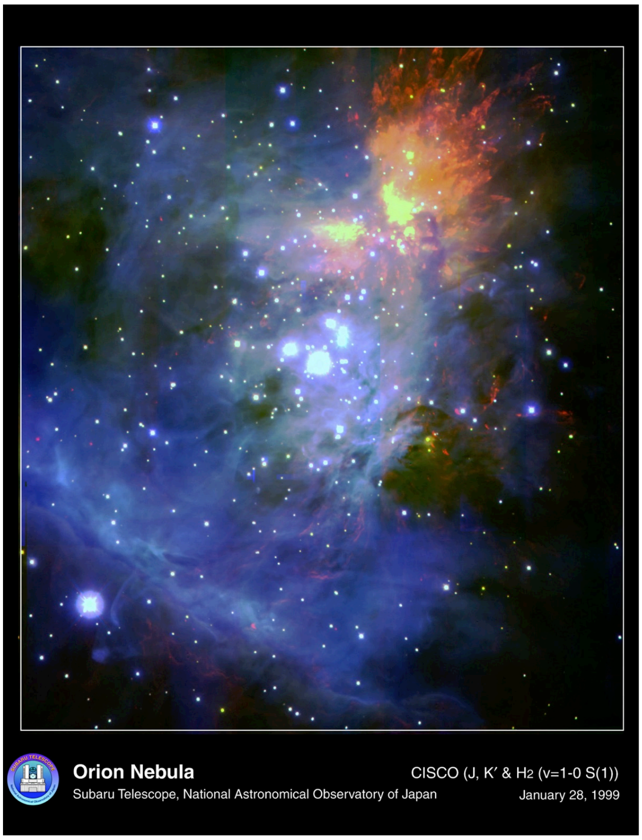
Subaru First Light Image : Jupiter & Saturn



Subaru First Light Image : Hickson Compact Group 40.



Subaru First Light Image : NGC4051, a Seyfert galaxy.



Subaru First Light Image : Orion nebula. Orion KL nebula is seen as red bipolar flow on the upper right.

Then the TV line was connected to the observation room on the mountaintop and images of the test observation team of the University of Kyoto and the University of Tokyo engaged in the observational work were shown. It was three o'clock in the afternoon in Tokyo, eight o'clock at night on Mauna Kea. Responding to the request of real image at the press release, images by the NHK High-Vision camera were shown. The telescope was smoothly directed to a nebula then to a stellar cluster. As the color image by the high-sensitive camera introduced the high power of Subaru Telescope, reporters unanimously uttered words of admiration. At the end of the press release, it was announced that the 'First Light' images would be put on the internet immediately, and the official press release came to an end.

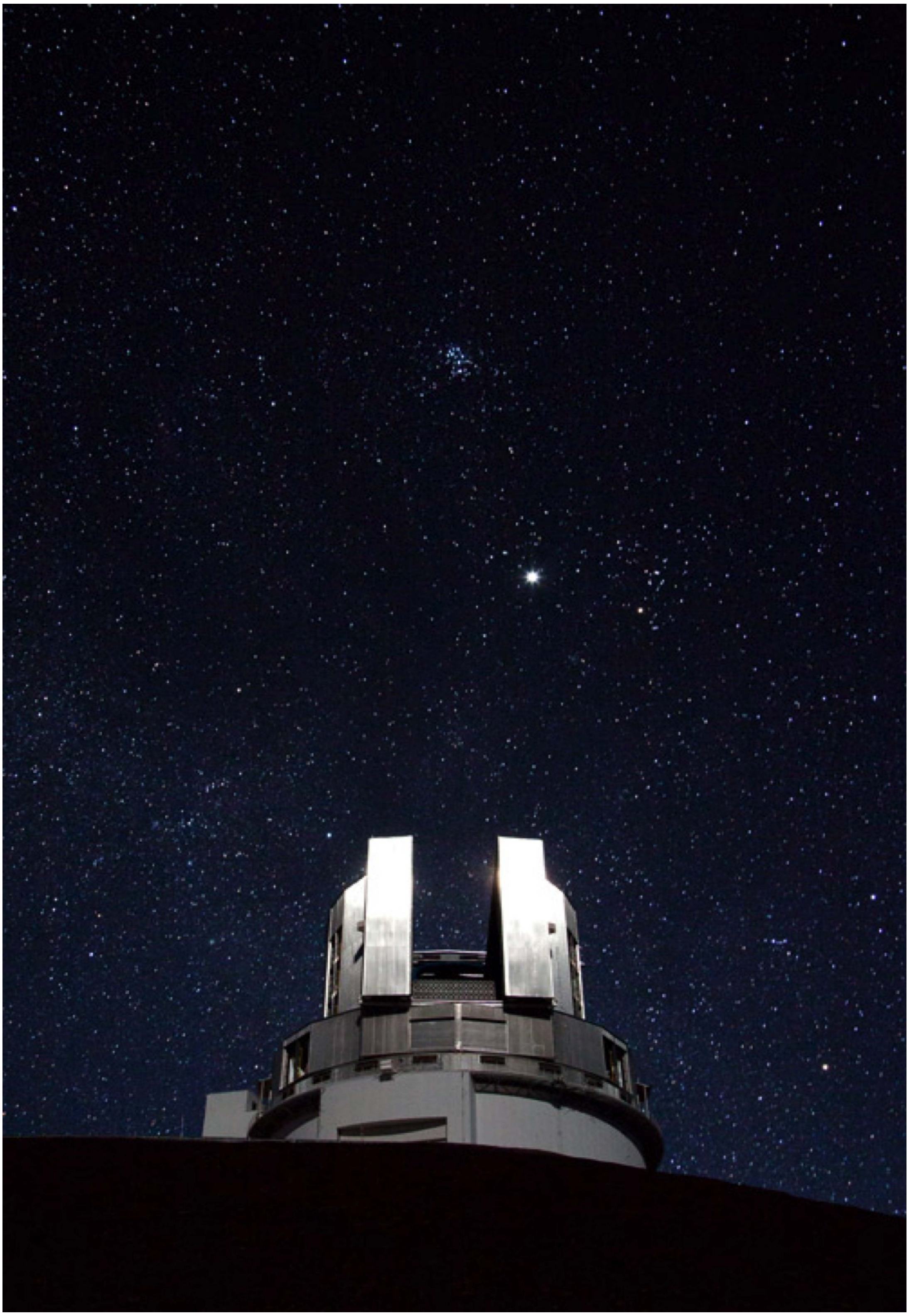
The room was filled with excitement. The TV screen was still showing the team members of Subaru Telescope. I saw on their faces delight and relief after the successful conference. To tell the truth, the most excited people when the press release ended were the researchers of NAOJ. They relied on this type of observational data on foreign countries. A part of the 'First Light' images, when analyzed, can be used as the basis of a research paper of a new discovery.

"The image of hydrogen molecules in Orion nebula looks like a big explosion in the water. It was known with the picture for the first time that a faint jet stretches to the outer edge."

"Let's write a paper with all the team members as the authors. I don't care how many the number of the authors may be."

"Be careful, though. The evaluation of the performance of the camera has not been done yet. It may contain ghost images by internal reflections."

Several people were waiting to make questions but the researchers of the observatory were apt to go into discussions. Soon, reporters, having finished with questions, got out of the press release room with materials of the First Light in their hands. In January 1999, after twenty and more years since the start of the study of the plan, the first results by Subaru Telescope was thus sent out to the world.



Subaru in the sky and Subaru on the mountain. The bright star in between is Jupiter (2013). ©NAOJ (photo by Mr. Pablo McLoud - Subaru Telescope)

[1] A poet specially invited to Utakai Hajime so that he presents a poem with the theme of the year.

[2] an annual New Year's Tanka [Poetry] Party at the Imperial Palace.

[3] a thirty-one syllable verse.

[4] Let us praise Subaru Telescope that started to work on Mauna Kea in order to study stars in the sky.

Postscript

This is a record of the trajectory of the Subaru Telescope Project, which was the first challenge for Japan to construct and operate a large national scientific facility on the soil of a foreign nation. The author felt almost inevitable to take a pen to record the personal emotional flows behind the streamline of the promotion of this big project, so that this book may not be completely objective record of the story of Subaru Telescope. The chronical records of the telescope construction, and the scientific and the technical achievements by the project, will be later published elsewhere, and the historical review of the background of the project promotion might also be edited from another point of view.

Author Keiichi Kodaira & his wife Uta Kodaira

The examination of the possibility about the construction of a big telescope on an appropriate location abroad out of Japan started late 1970s, and the National Large Telescope Project celebrated its groundbreaking in July 1992: Its dedication and the start of the operation are planned to be autumn 1999 and the spring 2000, respectively. Thus the author would be most happy if this book is also read as a kind of a life-history of an astronomer during the years when the after-war Japan had achieved the economic growth and successively went over to an unstable phase.

Now, the story of the project promotion has come to the end, while the long future story of the Big Telescope and the Subaru Observatory will just begin. The author is sincerely wishing the successful development of the Subaru Observatory, though one may still encounter various difficulties and may need even more efforts than ever to overcome them, dreaming that the spirit of this Subaru story be further entertained by the younger generation.

Towards the completion of this telescope, numerous people joined their forces and dedicated their efforts, and countless others lent them various supports. The author wishes here to express his deep gratitude and high respect to the persons named in this book and to those many others whose names could not be mentioned because of any sorts of restriction at the time of writing this edition.

The greatest support in producing the manuscript was provided by Mrs. Tei Masuyama, who appeared in this book as a secretary, in transferring the hand-written extracts from the author's diary of over thirty years into an electronic database. Further great supports in editing as a book came from the two members of the publishing company Bungei-Shunju, Mr. Hidemi Terada, Director of the First Literature Division, and Ms. Mitsuko Tanaka, editorial staff in charge for the present work, without whose abundant guidance and dedication this book would not have been completed. Once again the author wishes here to express his sincere thanks to them. The picture of the front cover, provided by the Subaru Project Office of NAOJ, was taken by Mr. Akihiko Miyashita, and the sketches on the chapter pages were occasionally drawn by the author during the years of the project promotion.

Keiichi Kodaira (author)
February, 1999

[Published] **Keiichi Kodaira/Kyoji Nariai**: **2016**, NAOJ-Books : Makali'i in Hawai'i.

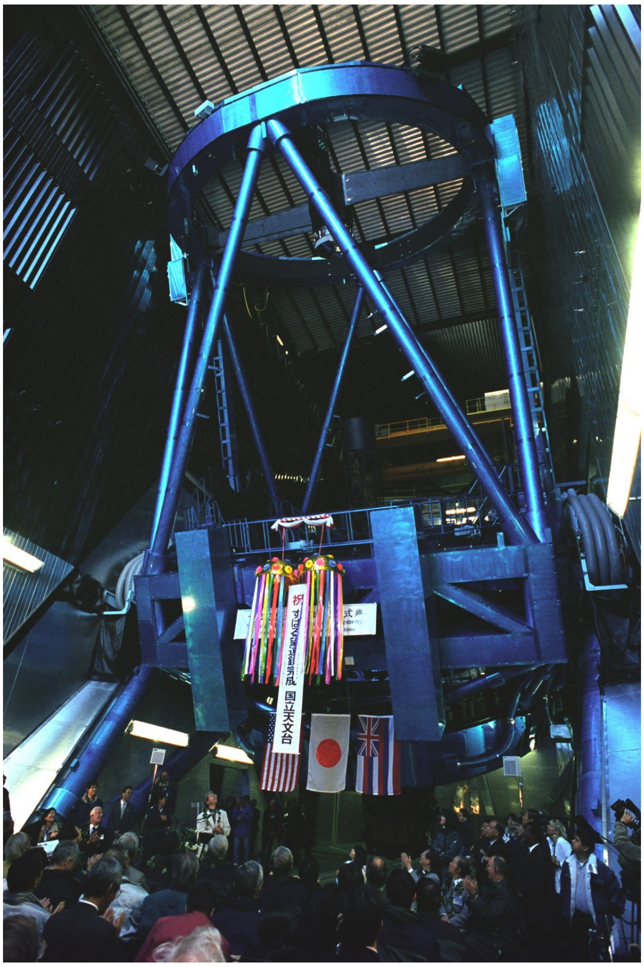
Appendix (Added for the English edition)

The original Japanese edition of this book (Uchuu no Hate Made=To the Edge of the Universe) was published by Bungei-Shunju two months after the first images were distributed at the press release that was held at three locations simultaneously, namely Mauna Kea, Hawai‘i, Ministry of Education, Science, and Culture, Minato-ku, Tokyo, and National Astronomical Observatory of Japan, Mitaka, Tokyo.

Half a year later, the ceremony of completion was held first at the telescope site on the summit, then at the Subaru Base Facility building in Hilo.

The author and his wife, Uta, had a chance to visit Hilo ten years later. They were happy to see the results achieved by the Subaru staff as well as the Kukui nut tree planted ten years before.

The movie of the Andromeda galaxy (=M31) was made with the digital image data obtained with the Hyper Suprime-Cam of the Subaru Telescope.

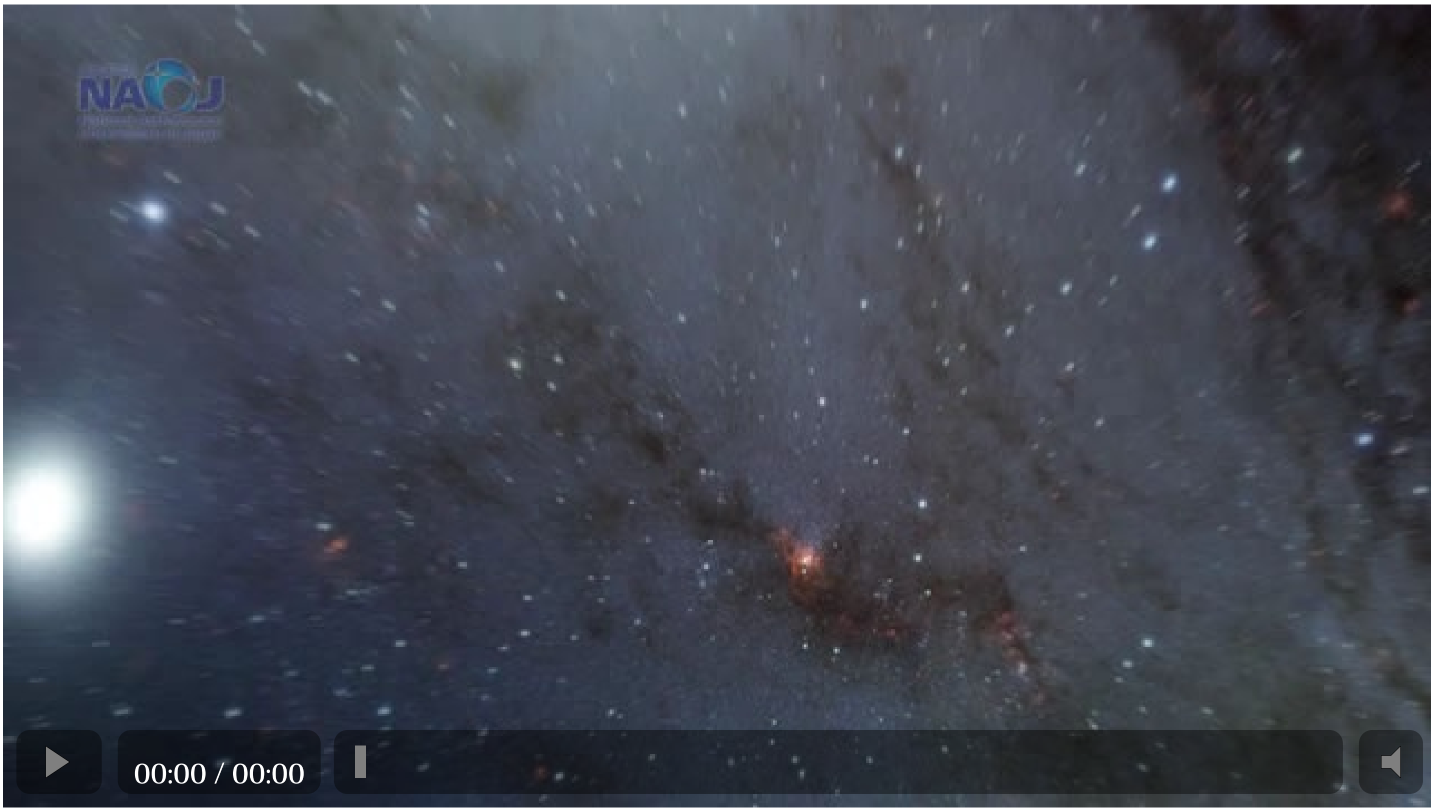


Subaru Telescope on the day of the ceremony for its completion.

In comemoration of the completion of Subaru Telescope, a Kukui-nut tree is planted by Princess Sayako.

Mrs. Uta Kodaira is looking up at the Kukui-nut tree planted by Princess Sayako ten years later.

M31(HSC) https://www.youtube.com/watch?v=zEDdxDPDtV0



Panoramic view of the Andromeda Galaxy. Subaru Telescope has been featuring very wide field imaging capability since the first light in 1999. The image shown here is taken by Hyper Supreme-Cam which began the operations in 2013. The new camera can take a view of nearly the whole Andromeda Galaxy with superb image quality. No other camera on Earth can do the same thing. In this way, Subaru Telescope is evolving over decades to solve enigmas of the universe. ©NAOJ

[Published] **Keiichi Kodaira/Kyoji Nariai**: **2016**, NAOJ-Books : Makali'i in Hawai'i.