Research in Kamioka and Kakenhi

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I have conducted research underground Kamioka, Gifu Prefecture, since I was a graduate student. The first experiment I participated in was the Kamioka Nucleon Decay Experiment (Kamiokande). The experiment was initially proposed by Professor Masatoshi Koshiba, who was my thesis advisor, to search for proton decay.

Professor Koshiba collaborated with a company to develop an unprecedentedly large 50-centimeter diameter photomultiplier tube (PMT) for the Kamiokande experiment. The PMT served a very important role in supernova neutrino observations that verified the supernova explosion mechanism and solar neutrino observations that confirmed the so-called solar neutrino problem. It is well known that, due to these achievements, Professor Koshiba received the Nobel Prize in physics in 2002.

It is common for a large apparatus such as this to be realized by submitting a budget request from a host institute after long, vigorous discussions in relevant researcher communities. In this case, however, the enthusiasm of the relevant researchers in view of the importance of Kamiokande experiments made it possible to realize the experiment quickly with funds from various sources. Kamiokande initially materialized through collaboration with the University of Tokyo's School of Science, to which Professor Koshiba belonged, the former National Laboratory for High Energy Physics (KEK), and the Institute for Cosmic Ray Research (ICRR) of the University of Tokyo. Although I was only a graduate student at that time and knew nothing about budgets, all of us participating in the effort recognized that people thought that this experiment was very important and endeavored to realize it as soon as possible.

Kakenhi played an important role in materializing the Kamiokande experiments. I heard that Professor Koshiba received Kakenhi support for the above-mentioned PMT development (Investigation of Proton Decay Experiment, Grant-in-Aid for General Scientific Research [A], principal investigator: Masatoshi Koshiba, FY1980–1981). There were naturally some costs that Kakenhi could not cover, such as excavating a cavity for

Kamiokande. Still, Kakenhi was important for the build-up of the equipment. At the time, one Kakenhi research category was called the Grant-in-Aid for Special Project Research. Apparently, a group of researchers applied for this in fiscal 1981. I am only writing by what others told me about what happened at the time, so my memory may not be totally accurate, but I heard that the application did not succeed that year, as the category did not assume project-based application. Still, reviews for such applications began with this category from the following year, and the application was accepted (Verification of Grand Unified Theory, Grant-in-Aid for Special Project Research, principal investigator: Saburo Miyake, FY1982–1984). So, Kakenhi was essential for making Kamiokande a reality.

Thereafter, Kamiokande observations began, largely supported by Kakenhi. As far as I know, the support from Kakenhi included the following:

- Proton Decay Experiment (Grant-in-Aid for General Scientific Research [A], principal investigator: Teruhiro Suda, FY1985–1986)
- Observation of Solar Neutrinos (Grant-in-Aid for General Scientific Research [A], principal investigator: Yoji Totsuka, FY1986–1987)
- Elementary Particle Picture of the Universe (Grant-in-Aid for Scientific Research on Priority Areas, principal investigator: Hirotaka Sugawara, FY1988–1990, with the planning team's project, Search of Proton Decay and Cosmic Neutrinos, principal investigator: Yoji Totsuka)
- Study of the nu_<mu>-deficit in the Atmospheric Neutrino Fluxes (Study of the Origin of Neutrino Mass) (Grant-in-Aid for Specially Promoted Research, principal investigator: Yoji Totsuka, FY1991–1994).

Because of Kakenhi, we were able to continue observations at Kamiokande and materialize the accomplishments mentioned earlier. Incidentally, my involvement in the above research was limited as being a co-investigator in several cases.

Owing to the above Kakenhi projects, I was in a good position at the time to engage freely in research using the Kamiokande data. In the late 1980s, I happened to notice that muon-neutrinos in atmospheric neutrinos generated by cosmic rays were far fewer than expected. Since then, I have been working on this problem. My first Kakenhi project to tackle it was Study of Atmospheric Neutrinos (Grant-in-Aid for Scientific Research [C], FY1995–1996). At that time it was already the end of Kamiokande, and the beginning of Super-Kamiokande. I thereafter received Kakenhi support continuously during the most important time for neutrino oscillation studies through atmospheric neutrino observations. Efforts included the following, and I remain grateful for the support:

- Precise Measurement of the Zenith-Angle Distribution of Atmospheric Neutrinos and a Study of Neutrino Oscillations (Grant-in-Aid for Scientific Research [B], FY1997–

1999)

- Precise Study of Atmospheric Neutrino Oscillations (a planned research as a part of Neutrino Oscillations and Their Origin [principal investigator: Yoichiro Suzuki] on Grant-in-Aid for Scientific Research on Priority Areas, FY2000–2003).

My research focus has shifted to gravitational waves. The effort entails building a laser interferometer with two three-kilometer arms underground in Kamioka to observe gravitational waves. The project is called KAGRA. The Ministry of Education, Culture, Sports, Science and Technology is supporting this endeavor. We receive substantial support, including the costs for the apparatus design, hiring researchers involved in its construction, and travel expenses through a Grant-in-Aid for Specially Promoted Research project, First Detection of Gravitational Waves Using Cryogenic Laser Interferometer (scheduled for FY2014–2018). Kakenhi is so important that I dare not contemplate what would happen if it were denied to us.

So far, I have presented my ties with Kakenhi, including for projects in which I was not directly involved. I believe that true progress on scientific paths comes from the free thinking of researchers. With research environments at universities and other academic institutions in Japan becoming rapidly impoverished, I believe that Kakenhi as competitive funding for supporting research based on free thinking is even more important. It seems no exaggeration to say that Kakenhi is the key to scientific progress in Japan even though the total amount is far from satisfactory.