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On the Works of HIKOSAKA Tadayoshi

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I would like to introduce HIKOSAKA Tadayoshi who reported a possible chain fission reaction of U238 by fast neutrons on November, 1944. In 1935 he submitted "Quantenstufen der Neutronen im Kerne". This report was the theoretical studies on neutrons in nucleus which showed the shell-like structure. He deceased on March 1989 at the age of 86.

HIKOSAKA Tadayoshi was born December 25, 1902 in Aichi prefecture, the central part of Japan Main Island. When he grew up, he desired to study physics. Tôhoku Imperial University at Sendai, 350km north from Tokyo, had the most advanced and active school of physics in Japan in early 1920s. So HIKOSAKA went to Sendai and graduated in physics from Tôhoku Imperial University in 1926. He was appointed Research Associate and worked on atomic spectra supervised by Professor TAKAHASHI. He mastered by himself the quantum mechanics.

From 1934, it was two years after the discovery of neutron, he examined theoretically the properties of neutron in nucleus. He reported his results in the Japanese journal, Kwagaku, in 1934¹⁾. Then he compiled his ideas comprehensively in "On Quantum States of Neutrons in Nucleus". He sent this manuscript to Physical Review, but the Editorial rejected it with disapproving comments of crazy idea. In those years every physicists could not accept the different concepts from BOHR's liquid drop model. He was, however, absolutely confident of his idea. So he rewrote his paper in German titled "Quantenstufen der Neutronen im Kerne" and submitted it to the Science Reports of Tôhoku Imperial University in 1935²⁾. This Reports were not widely distributed in and out side Japan. So his idea was not noticed by not only Japanese physicists but also European and American physicists.

In 1933 ELSASSER³⁾ pointed that the properties of nucleus varied with the number of protons and neutrons. It was three years later from HIKOSAKA's theory that WIGNER⁴⁾ reported the structures of nuclei described by the concept of independent orbits of neutrons and protons in nucleus. HIKOSAKA had gotten the idea of shell-like structure of nucleus 15 years in advance of the introduction of the shell-model by MAYER⁵⁾ and JENSEN⁶⁾.

This is one of the striking instances which too early pioneer advocate of new concept is not accepted, even, ignored completely. JENSEN's papers were also rejected by German journal in 1950.

HIKOSAKA was appointed Professor of Physics at Yamaguchi High School in 1939 and he visited Ôsaka Imperial University for studying the up-to-date nuclear

physics supervised by Prof. KIKUCHI for one year. In the late half of 1930s, using deuterons from Cockcroft-Walton accelerator, KIKUCHI and his colleagues got neutrons produced by D-D reaction and measured the cross sections for neutron scatterings from various nuclei⁷⁾. Their results showed the resonance like variations with Z of nuclei. DUNNING at Columbia University also measured the cross sections for neutron scattering from nuclei⁸⁾. DUNNING got neutrons from Ra-Be source. It was difficult to compare his results directly with KIKUCHI's experimental results, because energies of neutrons were different and DUNNING used not so many target nuclei.

HIKOSAKA calculated the cross sections based on his idea and showed successfully his results to be in good agreement with KIKUCHI's results. His idea was that the neutron scatters elastically by the neutron potential in nucleus and due to these potentials neutrons were caused the resonance scattering⁹⁾.

In early 1943 KIKUCHI asked HIKOSAKA to estimate a possibility of usage of nuclear energies from fission of Uranium. HIKOSAKA was appointed Professor at Dai Ni High School in Sendai. HIKOSAKA had considered deeply and calculated and reported his result orally at the Meeting of the Physico-Mathematical Society of Japan in the fall of 1943. His detailed calculation was presented at the Meeting of the Nucleus Section of the Committee of Scientific Researches on November of 1944. His report was titled as "The usage of Uranium fission energy." He said that in order to avoid difficulties of separating Uranium isotopes and of taking data for neutron moderators he calculated the mechanism of fission reaction of natural Uranium bombarded by fast neutrons. His results of calculation showed a possibility of chain reaction of fissions. His idea is the similar idea of the present "fast breeder reactor".

He eagerly asked KIKUCHI for going on experimental investigation following his calculation. However, that time when he presented his result was in the fall of 1944 and Japan appeared to be doomed to a defeat. KIKUCHI and the member of the Committee, NISHINA, TAMAKI, SAGANE, ASADA, and others, had no spare time to discuss more deeply and to examine HIKOSAKA's presentation further. KIKUCHI said that it was too late to go ahead for examining HIKOSAKA's idea and we could do nothing for further. And then the Meeting was closed in depressing atmosphere.

It was very sad even though in depressing doomed atmosphere at that time that nobody had not judged and not noticed the real worth of HIKOSAKA's presentation. His calculation was completely buried in oblivion. He wrote up his detailed calculation titled as "A Method for Use the Nuclear Energy." in Japanese. When HIKOSAKA and his family moved to Ryojun (Lü-shun, Port Arthur) Institute of Technology on April, 1945, he had handed his manuscript over to his former supervisor, Prof. TAKAHASHI of Tôhoku Imperial University for the Ph.D. dissertation.

On July, 1945 Sendai was air raided and burned out. HIKOSAKA's dissertation was also burned. However, fortunately HIKOSAKA had carried one of handwritten copies of dissertation with him to Lü-shun.

On October, 1945 Soviet Army ordered Japanese residents to move to Dalian. His family had spent very hard days there like refugees. In 1946 one of Soviet Army officers visited HIKOSAKA several times carrying the sweets and delicious foods. One day the officer told him that the Moscow Authorities tempted him to come Moscow where he was invited as the senior scientist for research on nuclear physics working with Soviet scholars. This is a guess that the Soviet Authorities had imagined the Japanese administration had sent HIKOSAKA to Lü-shun for conducting the construction of reactor and atomic bomb using Uranium in Korea and Manchuria. There was now no way to confirm the reality of this guess.

He discussed with his wife, Kyo, whether he should accept the Moscow's temptation or not. Kyo strongly objected, so he decided not to accept that invitation. After he told the officer his decision his family had spent very hard days only getting very small amount of foods.

His wife, Kyo, pasted every sheet of handwritten copy of his dissertation on the backing of basket-trunk concealing from person's attention. In the fall of 1949 they had come back Sendai carrying that basket-trunk. He was told that his manuscript of dissertation was burned at the same time the University's buildings burned out by the US air raid on July 1945. He immediately rewrote that copy and submitted it to Tôhoku University as his dissertation. The judging committee had decided that he would be given Ph.D. In early 1950 Japan was still in difficult situations of economy and industry, of foods, and of housings. The activities of the University were also not recovered. At this moment any of the member of the judging committee did not have composure to recognize the real value of his calculation.

In April, 1950 he was appointed Professor of Iwate University and obtained Ph. D. in physics at Tôhoku University. In June, 1951 he moved to Niigata University. He retired Niigata University in March of 1968 and came back Sendai. He got the job at Tôhoku Gaku-in University in April, 1968 and he lived at Tagajyo 15 km east from Sendai. He retired that University in March of 1978. He passed away at 19:40 on March 27, 1989 at the age of 86. He left his wife and four sons and three daughters.

In 1992 the Atomic Energy Society of Japan issued the journal of the special edition for 50th anniversary of chain reaction. HIKOSAKA's dissertation was reprinted in that edition and KATSURAGI, who is the atomic reactor engineer, reported the result of his examination of HIKOSAKA's calculation¹⁰). KATSURAGI's evaluation words are as follows: From 1940, due to the war, the foreign journals had not been brought into Japan, so HIKOSAKA could not have the sufficient data for his numerical estimations, e.g. the cross sections of fast and slow neutrons for Uranium fission, neutron energy spectra from fission, etc. Also in early 1940s Japanese scientists had not have electronic, even electric computers, so in order to get numerical values they had to calculate by hands picking up each values in the numerical tables of functions. HIKOSAKA had put several approximate equations of conditions for estimating the

fission probability. HIKOSAKA's processes are quite similar with which the present estimation for the reactors are dealt. HIKOSAKA's values of average number of fission neutrons are not so much different from the values obtained by the present detailed calculation. Concludingly HIKOSAKA's calculation showed the possibility of fast breeder reactor in 1944.

Prior to Atomic Energy Society of Japan issued the special edition of its Journal for 50th anniversary of chain reaction, KIMURA reported his examination of HIKOSAKA's calculation with the conclusion of the same evaluation¹¹⁾.

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