Shoji Nishikawa

1884–1952

No sooner had the news of the discovery of X-ray crystal diffraction by Laue, Friedrich and Knipping reached Japan, than Torahiko Terada (1878–1935), at that time an assistant professor at the Department of Physics, Faculty of Science, University of Tokyo, carried out his diffraction experiments using single crystals of rocksalt and other minerals. He observed, not only photographically but also visually by use of a fluorescent screen, the movement of the Laue spots as the crystal was gradually turned, and came to the conclusion that the diffraction spots might be explained as coming from simple reflections of X-rays from different netplanes in the crystal,[1] quite independently of W. L. Bragg. One evening, when this original visual observation was being made, Shoji Nishikawa (1884–1952), at that time engaged in the study of radioactivity as a post-graduate student under the guidance of S. Kinoshita at the same Department of Physics, was led by Terada into his room and shown for the first time the diffraction spots moving on the fluorescent screen in the dark. Encouraged by Terada, Nishikawa soon turned to the field of X-ray diffraction, where he made significant contributions to the analysis of crystal structure in the early period of its development.

Nishikawa was born in 1884 in Hachioji near Tokyo, a son of an important dealer in silk textiles, but he was brought up in Tokyo and finished his undergraduate course in physics at the Faculty of Science, University of Tokyo, in 1910. He was known to be very brilliant in his scientific ability and modest and shy in his personal character. After his graduation he became a postgraduate student and, by chance as described above, he devoted his later life mostly to the study of modern crystallography as well as to the education of numerous active research scientists in this field.

In 1913 he published, with his fellow student, S. Ono, his first paper, a diffraction study entitled 'Transmission of X-rays through

Fibrous, Lamellar and Granular Substances'.[2] For the fibrous substances, they took asbestos as the first example and obtained diffraction photographs with the X-ray beam in perpendicular or oblique incidence to the axis of the fiber. These photographs are nothing other than what are now known as fiber patterns, but taken with continuous X-rays. Assuming that the fiber consisted of innumerable minute crystallites in the uniaxial orientation with respect to the fiber axis, they could explain the characteristic features of these patterns on the basis of the reflection law of Bragg and Terada. They also observed fiber diagrams with fibrous gypsum, while they obtained negative results with quartz fibers or glass wool. In a similar manner they observed fiber patterns from organic fibers such as silk, wood, bamboo and *asa* (*Cannabis sativa*—a kind of hemp). Carbonized wood showed no discernible pattern. Similar experiments were extended to lamellar substances such as talc and mica. As for the granular substances, they first took marble, which showed a pattern corresponding to a spotted Debye-Scherrer diagram of later days. They also observed ring patterns produced with finely pulverized rocksalt, quartz, carborundum, etc., as early as 1913. Silica precipitated from its hydroxide showed no ring, while ordinary candle wax showed a pattern of concentric rings more or less similar to that obtained by Friedrich[3] a little earlier. In connection with these various kinds of substances, they investigated the diffraction effect of metals rolled in thin sheets. This investigation was suggested by the experiment of Hupka[4] with a platinum foil. The metals they examined were copper, iron, nickel, zinc, tin, lead, etc. For example, a rolled sheet of copper, when taken with the X-rays in normal incidence to the sheet, gave a pattern with ill-defined pairs of patches in the direction of rolling, which on annealing the sample became sensibly faint, and turned into a spotted ring pattern like that of marble. These experiments with metals were carried out quite independently of Keene.[5] Their first paper, then, contained the germs of later applications of the X-ray diffraction method to metallography and high-polymer science. The second paper by Nishikawa appeared in 1914, and in it the author recognized the possibility of utilizing the fibrous substances as analyzers of X-ray spectra and also found the determination of the netplane spacings.[6] Nishikawa then proceeded to the structure analysis of some crystals of the spinel group and magnetite by means of Laue photographs,[7] independently of similar work by W. H. Bragg.[8] What is significant to the history of the X-ray crystal analysis is his very early realization of the importance of the theory of space groups as a general and logical means of analytical procedure. He learned from Terada of the existence of this theory. In this connection it may be noted that Teiji Takagi, professor of mathematics, had been in Göttingen with D. Hilbert for some time, and Seiji Nakamura, professor of physics, had worked with W. Voigt; both were Terada's colleagues at this University of Tokyo. A collection of books on classical structure theories assembled by Y. Kikuchi, assistant professor of mineralogy at the Faculty of Science, University of Tokyo, was also available.

After publishing two more papers on crystal analysis, one on garnet [9] and the other with K. Hudinuki on nitrates of lead, barium and strontium,[10] Nishikawa and his colleague, Genshichi Asahara (*1891), were sent abroad for further study in 1917 by the newly established Institute of Physical and Chemical Research, Tokyo. They went first to the United States of America, but dislocations caused by the First World War made it difficult for them to find a suitable place for their purpose. After a time, Nishikawa finally visited E. L. Nichols at the Physical Laboratory, Cornell University, where he got acquainted with Wheeler P. Davey, then of General Electric Co., and Ralph W. G. Wyckoff, of the Chemistry Department. As seen in the preface to the first edition of the classical book *The Structure of Crystals* by Wyckoff, Nishikawa's meeting with Wyckoff may be said to have an implicit significance to the history of X-ray crystallography in the United States of America. Asahara, who had been engaged in some classical metallographic studies with W. Campbell at the School of Mines, Columbia University, then joined Nishikawa at Cornell, and there they carried out X-ray studies of metals such as aluminium, cadmium, copper, lead, silver, thallium, tin, zinc, and several kinds of brass, observing the effects of rolling and of annealing after rolling, and also trying to determine the transition points of thallium and tin by the change of X-ray patterns.[11] After the end of the War, Nishikawa crossed the Atlantic to England and stayed there for about half a year at the Department of Physics, University College, London, where W. H. Bragg was continuing X-ray crystallographic work using his famous ionization spectrometer.

In 1920, Nishikawa returned to Tokyo from abroad to organize and lead a research group, the Nishikawa Laboratory as it was called. In this position he was a chief research member of the Institute of Physical and Chemical Research. Using both the ionization spectrometer and diffraction photographs he began X-ray crystallographic investigations with his students Y. Sakisaka (*1893), I. Nitta (*1899), I. Sumoto and others, and, although a serious earthquake in 1923 and another in the next year interrupted the progress of the research work considerably, they recovered gradually and proceeded with their projects. When, in 1924, Nishikawa became professor of physics at the Department of Physics, Faculty of Science, University of Tokyo, he began giving lectures on X-ray physics and X-ray crystallography. Although the excellence of his lectures was well recognized by all students, his low voice, which resulted from his modesty and shyness, was a source of complaint.

During this period he was interested in the analysis of orthorhombic crystals, having made his own systematic absence table for the orthorhombic space groups. With the ionization chamber spectrometer made in the Institute, he measured reflections from a very good single crystal of aragonite, but, when he had nearly finished the structure analysis, he noticed that a paper by W. L. Bragg[12] on the structure of the same crystal had just been published, and he gave up completing the analysis. A similar circumstance occurred a second time to Nishikawa; when he had nearly determined the structure of α-quartz, he again found that a paper on the same subject by W. H. Bragg and R. E. Gibbs[13] had just appeared. Owing to the great distance from other scientific countries it was then very difficult for Japan to get current information from abroad.

His interest in structure and properties of quartz lasted for some time more. Thus he studied with Sumoto the α-β transformation by means of Laue photographs. Sakisaka made a series of experiments concerning the effects of surface treatment on the intensity of reflection, using various crystals, especially quartz.[14] Further, Nishikawa, Sakisaka and Sumoto investigated the effects of thermal strain[15] and mechanical vibration[16] on the intensity of reflection, using various crystals for the former and primarily quartz for the latter. All these subjects arose out of Nishikawa's keen interest in the problems relating to the extinction phenomena and crystal imperfections. This interest of his influenced numerous later studies carried out by his students as will be described in Part VI. Another basic contribution of Nishikawa is his ingenious experimental proof, with K. Matsukawa, that Friedel's law does not hold for the non-centrosymmetric crystal of zincblende;[17] this precedes the studies of D. Coster, K. S. Knol and J. A. Prins[18] and of I. G. Geib and K. Lark-Horowitz.[19] Besides his natural interest in the physical aspects of X-ray crystallography, Nishikawa had not a little interest in its chemical aspects and encouraged I. Nitta, a graduate of chemistry of the University of Tokyo, to undertake structure analyses of organic crystals, this field being rather new at that time. Also he introduced M. Nakaidzumi, at that time a post-graduate student of medicine, to the X-ray spectroscopic chemical analysis of human tissues by use of an ionization chamber spectrometer. Other students he introduced to X-ray crystallography included S. Shimura, a postgraduate student of metallurgy, and Z. Ooe, a student of mineralogy. Later all of the above mentioned became professors at the University of Tokyo and elsewhere.

Soon after the discovery of the electron diffraction by crystals by C. J. Davisson and L. H. Germer [20] and by G. P. Thomson and A. Reid [21], Seishi Kikuchi (*1902) published a series of papers [22] on photographic experiments of electron diffraction. These papers contained the discovery of the so-called Kikuchi-lines, -envelopes and -bands and are of historical importance. All these experiments of great significance were made by Kikuchi in a very short period of time by virtue of the wide experimental experience and the profound theoretical knowledge of his teacher Nishikawa. After these experiments the interest of Nishikawa's students was directed to electron diffraction, and, as will be described in Ch. 23, these students contributed considerably to the progress in the study of electron diffraction by crystals, assisted by the very relevant advice of Nishikawa. Thus he suggested them to use a spider's thread for supporting the powder, cathodic sputtering to prepare thin metallic films for reflection study, and the rotating crystal method with a knife-edge, etc.

In 1934 Nishikawa attended the General Meeting of the International Union of Physics held in London, and on returning to Tokyo next year he began to study with Nakagawa and Sumoto the slowing down of neutrons by paraffin. Further, with two eminent Japanese physicists, H. Nagaoka and Y. Nishina, he became engaged in building up the first cyclotron in the Institute of Physical and Chemical Research. In this field of nuclear physics he led I. Sumoto, T. Yazaki, K. Shinohara, S. Nakagawa, M. Kimura, M. Hatoyama and others on to problems such as the scattering of slow neutrons, artificial radioactivity, electron pair production, etc. up to the beginning of the Second World War. In 1937 he became a member of the Japan Academy. In 1945, immediately after the end of the War, he retired from his professorship at the University of Tokyo. Four years later, after thirty-two years of service he retired from the Institute of Physical and Chemical Research, and Shinohara, who was then a professor of physics at the Department of Physics, Kyushu University, succeeded him in the Institute. At the invitation of P. P. Ewald that Japan adhere to the newly established International Union of Crystallography, he organized in 1950, with T. Ito, S. Miyake, I. Nitta, R. Uyeda, T. Watanabé and others, the Crystallographic Society of Japan, and was elected to be the first President of the Society. At the same time the National Committee for Crystallography was formed within the Japan Science Council, and he was also chosen as the first Chairman of the Committee. The Second General Assembly and Congress of the International Union of Crystallography was held in Stockholm in 1951, and there Japan's adherence was approved. It was regretted that Nishikawa could not join this meeting because of his high blood pressure. He was confined to his bed, and, although he seemed better again, he died suddenly of apoplexy at his home on the 5th of January, 1952. In this way we have lost one of the most eminent scientists of Japan in the field of modern crystallography as well as experimental nuclear physics. By all of his friends and his students he is respected for his modest personality, his wonderful skill in experimental techniques and his profound understanding of theory.

A few lines may be added concerning his family. Soon after he became Professor of Physics at the University of Tokyo, he married Miss Kiku Ayai, a graduate of the Nara Women's Higher Normal School and once teacher of science at a girls' high school; they had four sons and one daughter. The first son, Tetsuji Nishikawa, recently became a professor of physics at the Faculty of Science, University of Tokyo, proving to be a good successor to his father.

I. Nitta

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