KIMURA LABORATORY (June 1950~March 1966)

Head: Dr. Kiichi Kimura

YANABU LABORATORY (February 1966~)

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and

RESEARCH LABORATORY OF NUCLEAR SCIENCE

Head: Dr. Sango Kunichika

Laboratories of Nuclear Science and Nuclear Reaction are successors to K. Kimura Laboratory, whose history until 1951 is described in this Bulletin[1]. Today the above two laboratories are working in close co-operation and their activities are not separable, so that the histories of the two laboratories are described here as a whole.

In 1951, when the Commemoration Volume of the Silver Jubilee[1] was published, the activities of K. Kimura laboratory covered a very wide range of pure and applied physics. The items of researches were: interaction of photons with matter, interaction of neutrons with matter, isotope production, natures of beta rays, instrumentation for radiation detection, interaction of charged particles with bulk material, nature of cosmic rays, system of high speed rotation of a magnetically suspended rod, application of photo-elasticity, properties of clay-water system, band structure of semi-conductors, high vacuum technique, ion sources for accelerators, electron linear accelerator and automatic measurement and selection of roller pins.

These fifteen items were investigated at the campus of the Department of Physics under the cooperation with staff members of the Department of Physics, Faculty of General Education and those of the Kyoto Prefectural University. Since 1952, when the construction of a fixed frequency cyclotron started, these investigations began to be transferred to the members other than the proper staff of the Institute for Chemical Research. The matter went as follows.

1) Photo-nuclear reactions such as (γ, 3α) reaction, (γ, p) reaction, (γ, n) reaction and the inverse process (p, γ) reaction were investigated mainly by the staff of the Department of Physics since 1952 and developed into the investigation of high energy photo-pion reaction using an electron synchrotron of the Institute for Nuclear Study, University of Tokyo.

2) Neutron induced reactions such as (n, α) reaction, (n,p) reaction and (n, γ) reaction were investigated by the members of the Institute up to 1952, and then these problems were studied by the members of the Department of Physics. The study of the neutron induced reaction was then replaced by that of the charged particle reaction

such as (p, α) reaction using an energy variable cyclotron of the Institute for Nuclear Study, University of Tokyo.

3) Isotope production study using a neutron beam from the Cockroft-Walton type accelerator still continued until 1956 and then transferred to the project of the Laboratory of Nuclear Science.

4) Back scattering of electrons and positrons from radioactive isotopes were investigated until 1954 and some mechanisms of the backward scattering were clarified. Multiple scattering of electrons or positrons by the atomic electrons was essential. Back scattering of gamma rays from radioactive isotopes was also investigated since 1956 and developed into the study of the radiation shielding.

5) End window type Geiger counters, gas flow type proportional counters, scintillation counters, scaling circuits, counting rate meter and other equipments for nuclear physics were developed until 1953. Then these studies were transferred gradually to production factories in Kansai district.

6) Energy loss of alpha particles in bulk material was investigated by the members of the Laboratory until 1952 and this investigation was stopped until 1965 when the alphs particles of 30 MeV became available.

7) Cosmic ray studies were abandoned since 1952 because the staff members in charge all changed their post.

8) Study of the high speed rotation was completed in 1952. This research aimed at the separation of stable isotopes in a strong centrifugal force field, but since the social need was not pressing at that time, and moreover, the construction of a cyclotron needed full power of the Laboratory, the investigation had to be stopped at its fundamental stage.

9) Mechanical properties such as friction phenomena, stress-strain distribution in a press fitted structure were studied by the use of photo-elasticity. Photo-elastic properties of gelatin-jelly were also investigated. These researches completed in 1952. The elasto-electricity of a human bone was also found and has been investigated by the staff of the Department of Medicine, Kyoto Prefectural University.

10) Electric property of clay-water system was investigated until 1951, and no advance was made since 1952. However, the research contributed to the establishment of Japan Industrial Standard of lead pencils.

11) Researches in the field of semi-conductor physics were abandond since 1951 because the staff in charge changed his post.

12) High vacuum technique has been continuously developed in the Laboratory. An oil diffusion pump with a long divergent nozzle was constructed and the design principle was applied to the big oil diffusion pump for the cyclotron evacuation.

13) To increase the beam intensity of the Cockroft-Walton type accelerator, the ion sources of vairous types were developed and their properties were investigated. Since 1952, these investigations were carried out by the members of the Department of Physics. Ion sources for the cyclotron were developed in the Laboratory since 1952.

14) Construction of a small betatron was tried from 1951 to 1952. Since this

year, the project was transferred to Konan University. The construction of an electron linear accelerator, described in the Commemoration Volume, was carried at Hyogo University of Agriculture since 1951.

15) The design and construction of an automatic selection device was completed in 1951.

In a word, as the researches in the field of nuclear physics were prohibited by the Supreme Commander of Occupation Forces in some period after the World War II, activities of the laboratory were compelled to turn to other fields, resulting some confusion in the course of the laboratory. The period from 1950 to 1953 may be called the era of re-arrangment of the laboratory, and in 1952, when the construction of a cyclotron started, an epoch was marked and then quite a new history has began.

The specifications, design and performance of the Kyoto University Cyclotron is described in an article in this Bulletin[2].

The design study was performed in 1952 and the construction completed in the end of 1955. The cyclotron laboratory was installed in an old brick building two kilometers apart from the University main campus, and researches of K. Kimura Laboratory has been done in this site since 1955.

From 1955 to 1960, main effort was made to construct the research instrumentations and radiation shielding walls and to revise some difficulties of the cyclotron found in the operation. In 1960, final form of the laboratory took shape and research works in the field of nuclear physics, nuclear chemistry and radiation biology have been commenced since then. In 1964, Laboratory of Nuclear Science was founded and separated from K. Kimura laboratory, but in reality, up to now, the Laboratory of Nuclear Science and the Laboratory of Nuclear Reaction are in a close co-operation.

As research works done in the cyclotron laboratory are reviewed in the recently published Decennial Report[3], here the contents of the Report are introduced briefly.

The Kyoto University Cyclotron is one of the middle class cyclotron and can accelerate protons to 7.5 MeV, deuterons to 15 MeV and alpha particles to 30 MeV. Research works done by the use of this cyclotron may be classified as follows.

1) Level structure and the excitation mechanism of light and medium weight nuclei.

By the method of inelastic scattering of protons, deuterons and alpha particles, the level structure and the excitation mechanism of nuclei from Li to Ni have been investigated.

The interests lie in such problems that collective mode of nuclear excitation appear or not in these nuclei as well as in heavy nuclei. The DWBA analyses of the elastic and inelastic scattering of alpha particles give good fit, but not so good for deuteron inelastic scattering. As a general rule, collective states are strongly excited independent of the incident particles. Efforts have recently been made to find non-collective state excitation such as unnatural parity states, excited core states and spin flipped states.

2) Reaction mechanism of light nuclei.

(p, α), (d, α), (α, d) and (α, p) reactions on light nuclei have been investigated. The interests lie in the problem that these reactions occur via direct process or compound process. Level structure of the residual nucleus was also studied from the standpoint of nucleon transfer mechanism. Recently (d,p) reactions and (d,t) or (d, He^3) reactions have been studied to search the core-excitation of the residual nuclei.

3) Structure of light nuclei.

Structure of light nuclei from Li to Ne has been studied by the method of quasi-free alpha-alpha scattering, scattering of polarized protons, break up of deuterons, elastic scattering between few nucleon systems and so on. Alpha cluster structure of Be^9 was clarified.

4) Accelerator physics.

Acceleration of heavy ions such as carbon and nitrogen multi-valued ions by the cyclotron has been developed since 1964. Recently the acceleration of He^3 ions was also attempted.

5) Radio-chemical studies.

Cooperating with the members of the Engineering Research Institue and the Department of Chemistry, Osaka University, radio-chemical studies of the rare-earth elements started since 1965. Deuteron induced reaction is the present main subject.

6) Radiation biology

The nutrition mechanism was studied by using radio-active pottasium and sodium produced by the cyclotron. Radiation injuries upon living bodies were also studied by the neutron irradiation.

7) Laboratory techniques.

High vacuum techniques and radiation detection techniques have been continuously developed by the members of the laboratories. Leak hunting method by using propane gas was established. Solid state detectors and accessory circuits have been widely used in the laboratory. Present effort is made on the fast circuitry development necessary for many particle correlation experiments.

In conclusion, since 1952, the efforts of the laboratory were concentrated to the construction of the Kyoto University Cyclotron, and then the interests of the members inclined to pure physics research rather than the application of nuclear physics to atomic power industries. This trend of the laboratory just coincides with the rise and fall of the atomic power industry in Japan, that is, the slowing down of the development of the atomic power industry in Japan brought us counterwise a chance to develop fundamental researches in nuclear science.

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III. Nuclear Reactions

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