ARTEM ISAAKOVICH ALIKHAN'YAN

(on his sixtieth birthday)

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ARTEM Isaakovich Alikhan'yan, a well-known Soviet physicist in the field of nuclear physics, cosmic rays, and elementary particles, corresponding member of the USSR Academy of Sciences and full member of the Armenian Academy of Sciences, celebrated his sixtieth birthday on 24 June 1968.

While still a student, Alikhan'yan was attracted by that atmosphere of romantic research, which determined the outline of all his subsequent activity. Already in his second year at the Physics Department of the Leningrad State University, Alikhan'yan started to take part in seminars held by A. F. Ioffe at the Leningrad Physicotechnical Institute. Ioffe called attention to the capable student and his love for knowledge, and contributed greatly to his subsequent creative growth.

In 1930, Alikhan'yan began to work as a scientific assistant at the Leningrad Physico-technical Institute. His first investigations were devoted to the physics of crystals, x-rays, and diffraction of fast electrons.

Soon, however, his interest was aroused by the atomic nucleus, the puzzling properties of which began to interest more and more physicists of the entire world. Since that time, Alikhan'yan remained through the succeeding years attracted to precisely this field of physics, and together with I. V. Kurchatov, D. V. Skobel'tsyn, A. I. Alikhanov, and L. A. Artsimovich, and others he pioneered the development of experimental nuclear physics in the Soviet Union. Because of his particular knowledge, tremendous ability for work, and ability to devote himself entirely to science, Alikhan'yan was always in the forefront of the main trends of the development of elementary-particle physics.

In 1934 Alikhan'yan, with his brother A. I. Alikhanov and with M. S. Kozodaev, investigating the production of positrons in radioactive decay, discovered a new phenomenon, the internal conversion of gamma rays with production of electron-positron pairs. In 1936, Alikhan'yan proposed an experiment and proved, together with A. I. Alikhanov and L. A. Artsimovich, the validity of the energy and momentum conservation law in positron annhilation. This was the first experimental proof of the conservation of these laws in an elementary act, concerning which many doubts were expressed during that time, particularly by N. Bohr.

Soon after the discovery of artificial activity (with positron emission) by the Joliot-Curie husband-and-wife team, Alikhan'yan and his co-workers discovered the first artificial radioactive element (silicon) emitting negatively charged electrons. This discovery has made it possible to understand why the sign of the charge of the electrons emitted in beta decay is determined by the ratio of the proton and neutron numbers in the nucleus, as was explained soon thereafter by N. Bohr.

During the same time Alikhan'yan and A. I. Alikhanov investigated the beta spectra of artificial radioactive elements and established the dependence of the energy spectrum of the electrons and positrons of the charge of the decaying element. At the same time Alikhan'yan and K. I. Korsunskaya were the first to observe the irregular growth of the yield of radioactive phosphorus when aluminum is bombarded with alpha particles of different energies, thus indicating the existence of discreet energy levels of the compound nucleus.

In 1937, Alikhan'yan proposed for the first time and started, together with A. I. Alikhanov, experiments on the observation of recoil atoms produced when orbital electrons are captured from the K shell of the Be^7 nucleus, in order to prove experimentally the existence of the neutrino. They performed the first experiment, in which Li^7 recoil nuclei were observed. The war interrupted these researches. In 1942, the American physicist Allen performed almost exactly the same experiment, indicating the emission of a neutrino upon capture of an orbital electron by a nucleus.

During the same time (1937–1941) Alikhan'yan, together with A. I. Alikhanov and A. O. Vaĭsenberg, performed precise investigations of the scattering of relativistic electrons by nuclei of different elements, in order to verify the Rutherford-Mott formula. At that time the experimental data on this topic were quite contradictory, deviating from theory by a factor as much as 100. Alikhan'yan et al. obtained the first quantitative data on the scattering of relativistic electrons, in splendid agreement with the predictions of quantum electrodynamics. Only in the case of gold was the experimentally observed scattering smaller by a factor 2.5 than predicted by the exact formulas for the gold nucleus. However, already during the time of the war, the American theoreticians recalculated the scattering cross sections and their final result agreed with the experimental data of Alikhan'yan et al.

At the start of the second world war Alikhan'yan worked in Kronstadt on USSR navy projects.

In the late 30's, physicists engaged in research on the atomic nucleus began to be attracted by cosmic rays as sources of high-energy particles. Even before the start of the war, Alikhanov and Alikhan'yan called attention to the presence of an anomaly in the behavior of the soft component of the cosmic rays. The soft component revealed a larger ionizing ability than expected on the basis of the composition known at that time (electrons, positrons, muons, and photons). Alikhanov and Alikhan'yan advanced the hypothesis that the soft component of cosmic radiation contains also protons.

In 1942, Alikhan'yan together with Alikhanov and co-workers moved to Armenia, where they organized a laboratory and, in spite of the wartime difficulties, proceeded to a systematic study of cosmic rays on the Aragats mountain, at an altitude of 3200 meters above sea level. Already in the first years of the investigations, Alikhan'yan and co-workers have shown that at mountain altitudes the cosmic rays contain an intense flux of fast protons, amounting to approximately 10% of the total radiation at these altitudes. This fundamental result has tremendous significance for the entire study for cosmic rays, since it is precisely the fast nucleons which cause all the basic processes occurring when the rays pass through the atmosphere and lead to the appearance of all the remaining types of particles contained in the cosmic radiation. It is just this circumstance which stimulated the construction during the post-war years of the first high-energy proton accelerators. In particular, Alikhan'yan and E. G. Komar developed the first variant of the design of the first Soviet proton synchrotron.

Alikhan'yan and his co-workers have observed intense generation of protons by fast neutrons, and have shown that the cross section of charge exchange of protons and disintegration of nuclei by fast protons is close to the value of the geometric cross section of the nucleus.

In 1943, Alikhan'yan together with T. L. Asatiani and N. V. Shostakovich, discovered showers of a new type, which they called "narrow showers." The discovery of these showers revealed for the first time non-electromagnetic nuclear processes that occur intensely when cosmic radiation passes through the atmosphere. At the same time, Alikhan'yan proposed and implemented a new method of investigating the structure of showers, the so-called method of "area variation," which made it possible to observe in the composition of the primary cosmic radiation particles with very high energies, on the order of 10^{17} eV. In the last 20 years this method has become the main method of investigating extensive air showers in the entire world.

In the same 1943, Alikhan'yan organized in Erevan the physics institute of the Armenian Academy of Sciences, whose director and leader he remains to this very day.

As a result of the energetic activity of Alikhan'yan and his students, there was created on the Aragats mountain a first class high-altitude station for the study of cosmic rays, equipped with modern technical equipment and with unusual apparatus.

In the same years Alikhan'yan, Alikahnov, and their co-workers proceeded to a systematic study of the nature and spectra of the cosmic-ray particles with the aid of a new method developed for this purpose, called the Alikhan'yan-Alikhanov magnetic mass-spectrometer method.

In the first stage of the application of this method, Alikhan'yan and his co-workers obtained the first indications that there exist particles with masses intermediate between those of the muon and the proton.

These investigations were continued in subsequent years, but their further development encountered great difficulties, since the new particles observed in the mass spectrometer and most intensely generated by the cosmic rays, subsequently called pions, imitated the appearance of heavier particles in the apparatus. Failure to take this circumstance into account led in many cases to incorrect results. However, the ideas formulated for the first time in these investigations, namely the existence of a large number of new unstable particles that are mutually transformed into one another turns out to be fruitful and was confirmed in subsequent investigations.

The pioneering investigations initiated on Aragats in 1945–1946 by Alikhan'yan, Alikhanov, and their co-workers stimulated a large number of investigations aimed at finding new particles in cosmic rays, carried out in different parts of the world for approximately ten more years.

By greatly improving the magnetic mass spectrometer used in conjunction with a cloud chamber, Alikhan'yan and his co-workers have shown in 1950–1952 that particles with masses intermediate between the mass of the pion and that of the proton have a relatively large lifetime, more than 5×10^{-9} sec. It was subsequently established that the lifetime of the K meson is $\sim 10^{-8}$ sec. Somewhat later, under Alikhan'yan's initative and direction, the Nor-Amberd cosmic station was organized on the slope of the Aragats mountain, devoted to a systematic investigation of the interaction between high-energy nucleons and nuclei, and also to methodological investigations. The Aragats and the Nor-Amberd stations are the first cosmic stations operating the year round in the USSR.

In the middle 50's, the center of gravity of the interest of the physicists engaged in elementary particles started to shift towards experiments with large accelerators. During these years, Alikhan'yan and his co-workers performed research concerning different properties of elementary particles. In particular, an investigation of the $\pi \rightarrow \mu \rightarrow e$ decay observed in bubble chambers, confirmed the violation of the parity conservation in this process. An investigation, the most accurate of its day, was performed on the scattering of muons by nuclei. Most interesting from among these investigations was the experimental study of the decay of the long-lived neutral K_2^0 meson into three neutral pions. Such a decay follows directly from the conservation of CP-invariance, and its verification was of fundamental interest. The experimental solution of this problem was connected with development by Alikhan'yan and co-workers of the 570-liter freon bubble chamber, then the largest in the world, with the aid of which it was possible to observe more than hundreds of cases of the investigated decay.

In 1957, a new important stage began in Alikhan'yan's scientific biography. In that year, at Alikhan'yan's initiative and under his direction, the construction was initiated of the largest electron synchrotron in the Soviet Union and one of the largest in the world, rated 6 GeV. The construction of such an accelerator at the Physics Institute of the Armenian Academy of Sciences, and subsequently at the Erevan Physics Institute of the State Committee on the Utilization of Atomic Energy in the USSR, was a logical consequence of Alikhan'yan's entire earlier scientific activity and that of the staff of scientists directed by him. The design, construction, and starting of the "ARUS" synchrotron, which was realized on the 50th anniversary of the October revolution, proved the mettle of the staff of the institute, and in Alikhanyan's case was evidence of his ability to cope with the most difficult scientific and organizational problems. At the present time, intense preparatory work is being performed on the "ARUS" accelerator for experiments in which Alikhan'yan takes very active part.

Besides the physical research, Alikhay'yan has paid strict attention in recent years to the creation of new methods of detection and measurements of momenta of particles of high and ultrahigh energy.

Alikhan'yan and his co-workers are pioneers in the creation of a new type of spark chamber, the so-called tracking spark chamber. Developing and improving spark chambers with a large discharge gap, Alikhan'yan and his co-workers placed such a chamber in a strong magnetic field and proved the possibility of exact measurement of the momentum of the charge particle in a spark chamber. These chambers make it possible to obtain much greater information on phenomena occurring in the working volume of the chamber, than the universally known spark chambers, and is successfully used in many of the largest centers of the USSR, USA, and Europe.

Alikhan'yan and co-workers also performed investigations aimed at confirming the absence of the density effect in thin films of scintillating matter, and have demonstrated that this can be used to measure the energy of ultrafast particles. A procedure was also developed for the detection of hard transition radiation emitted in a layered medium, and suitable experiments were performed. At the present time investigations in both these directions are continuing, and there are all grounds for assuming that they will lead to the creation of a new method of determining the energies of the individual particles and their identification at such energies, when the Cerenkov method becomes inapplicable.

During the last ten years, the Erevan Physics Institute has grown into a mighty center of scientific research. This institute, directed for 25 years by Alikhan'yan, is well-known in the entire world for its research in the field of cosmic rays and elementary particles, electro-dynamics, accelerator theory, and new methods of recording elementary particles. The elementary particles laboratory of FIAN, directed by Alikhan'yan, also has made great progress in the development of spark and bubble chambers and scientific research with the aid of these and other instruments. It played a major role in the scientific training of the physicists of the Erevan Physics Institute.

Alikhan'yan enjoys wide fame and respect among foreign physicists; he has been invited many times and took active part in the largest international conference on high energy physics and particle accelerators, delivered lectures in the largest nuclear centers in the USA and Europe, and particularly at the Harvard University.

At Alikhan'yan's initiative, an annual school of experimental and theoretical physics has been held during the last five years at the Erevan Physics Institute. Taking part in the activities of this school are the leading scientists of the Soviet Union, and recently also foreign scientists, and its proceeding are published annually for the general editorship of Alikhan'yan. The school enjoys wide popularity among the foreign physicists, and some of its proceedings have been translated in a number of countries. The school headed by Alikhan'yan attracts a large number of capable scientific youths and is a very useful form of increasing the skill of young scientists. Great work on the organization of Soviet physicists and expansion of its connections with foreign scientific centers is carried out by Alikhan'yan at the Division of Nuclear Physics of the USSR Academy of Sciences.

Alikhan'yan, jointly with A. I. Alikhanov, was awarded a State Prize of second degree for scientific research on radioactivity, carried out up to 1940. For work on cosmic rays and the nature of elementary particles, Alikhan'yan and Alikhanov were awarded a State Prize of first degree in 1948.

During the entire time of his scientific activity, Alikhan'yan published approximately 150 papers on nuclear physics, elementary particles, and accelerators.

In 1943, Alikhan'yan organized the department of the atomic nucleus in the Erevan State University, and 1946 he organized the department of nuclear physics at the Moscow Engineering-Physics Institute and led this department until 1960.

Alikhan'yan trained more than one generation of physicists who are fruitfully working in the field of cosmic rays and elementary particles. Among them

are Corresponding Members of the USSR Academy of Sciences V. P. Dzhelepov and P. E. Spivak, corresponding member of the Armenian Academy of Sciences N. M. Kocharyan, Doctors of Physical-Methematical Sciences A. O. Vaisenberg, V. G. Kirillov-Ugryumov, M. S. Kozodaev, S. Ya. Nikitin, V. M. Kharitonov, and many others.

Alikhan'yan reaches his sixtieth birthday in full bloom of his creative powers and full of extensive scientific plans. We wish him sincerely good health and the same inexhaustible energy.

Translated by J. G. Adashko