Abram Isaakovich Alikhanov (obituary)

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Academician Abram Isaakovich Alikhanov, an outstanding Soviet experimental physicist and one of the founders of nuclear physics in our country, would have observed his seventieth birthday in March of 1974.

Alikhanov's contribution to the development of science was a very great one. It goes beyond his personal scientific achievements and is best stated in terms of the guiding and organizing role that he consistently played in physics, shaping new scientific trends, attracting whole scientific staffs to work in these trends, and motivating them powerfully with his own creative activity.

Alikhanov supervised the construction of heavy-water nuclear reactors during the period in which atomic energy was being mastered. To the end of his life, he remained the chief proponent of the heavy-water trend in reactor construction.

In the early 1950's Alikhanov was one of the first individuals in our country to recognize the need for rapid development of fundamental research in high-energy physics, and he became a motive force behind construction of the Serpukhov accelerator.

For all of the many facets of his scientific career, Alikhanov was primarily an experimental physicist—an experimentor in the highest sense of the word, as exemplified by Faraday and Rutherford. This was manifested in the eagerness with which he received all new experimental results, in the enthusiasm with which he introduced the most recent ideas in the procedure of physical experiments in his laboratory and at his institute. An acute appreciation for innovation in physics was characteristic of Alikhanov throughout his entire life.

Alikhanov was born into the family of a locomotive engineer at Kars on March 4, 1904. He passed his school years at Tiflis, removing to Leningrad after acquiring his secondary education.

He received his higher education at the Leningrad Polytechnic Institute, graduating in 1928 in the Physico-mechanical Faculty, which had been founded by A. F. Ioffe. Alikhanov began scientific work at the Leningrad Physico-technical Institute while still a student. During those years, the basic scientific subject matter of the LPTI consisted of research in x-ray physics, solid-state physics, and x-ray diffraction. Alikhanov's first published paper was devoted to the use of x-ray analysis in investigating the crystal structure of certain alloys.

In the period from 1930 through 1933, Alikhanov collaborated with L. A. Artsimovich in a series of studies in x-ray optics. Among the papers written at that time, special note should be taken of a study of total internal reflection of x-rays from thin layers of various substances. Subtle and difficult experiments whose performance required enormous experimental skill demonstrated for the first time that the classical optics of Fresnel and Maxwell is applicable to phenomena of reflection of hard x-rays from transparent and absorbing media.

In 1933, Alikhanov's focus of attention shifted to a range of problems that was new in the USSR—the investigation of the atomic nucleus—at the same time as those of Igor' Vasil'evich Kurchatov. The discovery of the neutron, which radically changed the prevailing conceptions of the nucleus, research on the splitting of light nuclei by accelerated particles, and a number of other landmark discoveries by physicists of foreign countries stimulated an extraordinary interest in nuclear physics both in the West and in the USSR. Alikhanov was one of the first Soviet physicists to take an active interest in this "subatomic" range of the structure of matter. The direction that he chose was that of studying the then still exotic process of positron production by γ rays in the Coulomb field of the nucleus.

Alikhanov began with the development of an effective method for study of positron energy spectra. He introduced radical improvements into the classical magnetic spectrometer with transverse field, fitting it with a system of coincidence-coupled gas-discharge counters. The use of this registration system was an important

methodological novelty. It opened the way to development of Soviet nuclear electronics, which has been advanced in many of its aspects by Alikhanov's students. The new magnetic spectrometer was capable of registering the comparatively infrequent processes of positron production and could be used to investigate their energy spectra, the dependence of positron yield on γ-quantum energy and on the atomic number of the element, etc.

The γ-radiation sources in Alikhanov's experiments were preparations of naturally radioactive elements. Gamma-quanta that they emitted with sufficiently high energies were converted to electron-positron pairs in lead foil. In the course of his investigation, Alikhanov discovered that positrons were present even in the absence of a converter made from a heavy element, and this led him to the discovery of a new phenomenon—production of an electron-positron pair as a result of internal conversion of the energy of the excited nucleus. A theoretical analysis of the new effect was given by Robert Oppenheimer. Theoretical and experimental investigation of pair conversion later made it possible to use this phenomenon as an effective tool in nuclear spectroscopy. Two other trends developed during the prewar years by Alikhanov and his students consisted, firstly, in study of the scattering and deceleration of fast electrons in matter and, secondly, in study of the form of the beta spectra of radioactive substances. During those years, both of these problems were of considerable fundamental interest. The investigations of the scattering of fast relativistic electrons that were carried out in Alikhanov's laboratory showed that all of the basic relationships in this phenomenon are described satisfactorily by Dirac's relativistic theory. Study of β spectra led Alikhanov and A. I. Alikhan'yan to a conclusion as to the nature of the effect of the nuclear Coulomb field on the form of the electron-positron spectrum (the shape of the spectrum was found to depend on the atomic number of the element). Among the studies of this period, an elegant experiment that confirmed the validity of the energy and momentum conservation laws in positron annihilation stand out as something of an oddity. This experiment was designed in connection with a discussion initiated at the time by Niels Bohr concerning the validity of the conservation laws in elementary interaction events between microparticles.

Another highly important experiment was begun in Alikhanov's laboratory in 1940. It consisted in observation of the recoil experienced by the Li I nucleus on emission of a neutrino by a radioactive Be I nucleus in the process of orbital-electron capture. The conviction that the neutrino does indeed exist was not by any means universally held at that time. The neutrino hypothesis predicted a nuclear recoil of quite definite magnitude on electron capture, and its observation would have proven the emission of such a particle in β processes. The experiments were interrupted by the outbreak of the Second World War. (This experiment was performed in 1943 by Allen.)

Also during the prewar years, Alikhanov found his attention drawn to elementary-particle physics. In his laboratory, he organized a series of studies of the cosmic radiation—the only source of high-energy particles known at that time. An expedition into the high mountains of the Pamir was made ready in 1941 to further a broad program of such studies, but the war intervened.

The investigation of cosmic rays was resumed in 1942 on Mount Aragats in Armenia. The presence of an intense group of protons with comparatively small energies in the soft cosmic-radiation component was discovered as a result of the first expeditions.

In 1943, work was begun in the USSR under the general scientific supervision of I. V. Kurchatov toward the harnessing of atomic energy. Working with Kurchatov, Alikhanov became involved in the development of the most difficult scientific and technical problems that were encountered here and became the director of the emerging field of the physics and technology of heavy-water nuclear reactors.

To the end of his days, Alikhanov was a committed partisan of the heavy-water trend in reactor construction. He was aware of the technical difficulties astride the path of progress in this direction, but they did not intimidate him, and, brilliant experimental physicist that he was, he was invariably coming up with elegant solutions.

In 1945, Alikhanov organized a new scientific center for research on nuclear reactors and in nuclear physics; it is now known as the Institute of Theoretical and Experimental Physics (ITEP). Alikhanov headed this institute for nearly 25 years, and it was here that his brilliance as an organizer can be fully appreciated. The stimulating creative atmosphere that Alikhanov developed in the Institute that he headed attracted first-class scientific talent to it, including such outstanding theoretical physicists as I. Ya. Pomeranchuk, who headed the theoretical division, and L. D. Landau, who was a friend of Alikhanov's of many years' standing.

Under Alikhanov's leadership, his institute quickly gained respect among the country's institutes of physics. In 1949, a heavy-water research reactor was commissioned at the ITEP. Work on the development of this first heavy-water reactor had been completed in record time, even by present-day standards: design of the reactor had been started in 1947, it was built in 1948, and the first critical experiment was conducted with it in April of 1949. Alikhanov worked on the development of the reactor not only as head of the institute and scientific project director, but also directly, solving all of the physical and technical problems that arose in construction of the reactor, and tackling the dirtiest jobs without hesitation; thus the reactor was for the most part his creature. Even though there was no exchange of scientific information on nuclear reactors with other countries during those years, and Soviet work in this field was begun considerably later than in the USA on account of the war, the heavy-water research reactor built at the ITEP was later found to perform on a par with the best foreign reactors. With this reactor, Alikhanov and his co-workers made measurements of nuclear-physical constants that were important for the design and construction of other reactors and accumulated necessary operating experience. Thus were the foundations laid for the great task of building heavy-water reactors. Experimental heavy-water reactors were developed and built in the USSR and abroad under Alikhanov's direction.

For his outstanding service in the field of reactor construction, Alikhanov was named a Hero of Socialist Labor and awarded a First Degree USSR State Prize in 1954.

A new stage in Alikhanov's scientific career began in 1957, in connection with the discovery of parity violation

in weak interactions. With his characteristic energy, Alikhanov became the Soviet Union's first investigator of the problems that arose here. In 1957, he and his co-workers measured the longitudinal polarization of electrons in β decay. Study of longitudinal electron polarization in the β decay of RaE made it possible to establish conservation of temporal parity in weak interactions. Measurements of the sign of the longitudinal polarization of muons in $\pi \to \mu + \nu$ decay that were made by Alikhanov and his co-workers made it possible to determine the helicity of muons in this process and to conclude the presence of a V—A interaction in $\pi\mu$ decay.

Beginning in 1952, Alikhanov began to develop the idea of building high-energy accelerators operating on the strong-focusing principle in the USSR. He attacked this problem with his usual confidence, despite objections from certain authorities. With V. V. Vladimirskii, he initiated research on the design and construction of a strong-focusing 7-GeV proton accelerator at the ITEP as a basic prototype, and advanced the work toward the creation of the 70-GeV Serpukhov accelerator. The work on the ITEP proton accelerator culiminated with its startup in 1961. The coming on line of the 7-GeV accelerator made possible the development of research in elementary-particle physics on a broad front at the ITEP.

Alikhanov participated most actively in the elaboration of scientific research problems for the ITEP accelerator. Among the projects that he carried out on this accelerator, special note should be taken of the study of pion scattering on nucleons with large momentum transfer.

Alikhanov always devoted a great deal of attention to development of experimental techniques. At his initiative, scintillation techniques, bubble and spark chambers, and many other methods were advanced in the ITEP.

He also participated actively in the work of the Division of Physico-mathematical Sciences of the USSR Academy of Sciences (he was elected a corresponding member of the USSR Academy of Sciences in 1939 and an Academician in 1943). He was one of the organizers of the Nuclear Physics Division. He created a large school of physicists, many of whom have enjoyed eminence among scientists.

Alikhanov's activity in physics and reactor construction were recognized with high governmental honors: he was a Hero of Socialist Labor and held three Orders of Lenin, an order of the Red Banner of Labor, and USSR medals.

Alikhanov was extremely straightforward and generous in his dealings with people, irrespective of whether the matter was a scientific or a merely personal problem. His broad scientific perspective and his lively interest in new problems, not only in physics, but also in science in general, always lent creative interest to conversations with him.

The last years of Alikhanov's life were darkened by a grave illness. But he continued working as he fought it. The end came on December 8, 1970.

Abram Isaakovich Alikhanov traveled a long scientific path. Although the journey was by no means always simple and easy, he always remained a man of high principle distinguished by a genuine love for science.

Translated by R. W. Bowers