![Portrait of Abram Fedorovich Ioffe](image)

1960

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Portrait of Abram Fedorovich Ioffe

Figure 1: Portrait of Abram Fedorovich Ioffe

Abstract

Full Text

ABRAM FEDOROVICH IOFFE

(29 X 1880–14 X 1960)

On October 14, 1960, one of the greatest Soviet scientists, Academician Abram Fedorovich Ioffe, passed away—the founder of modern physics of semiconductors and dielectrics. The formation and development of physics in the Soviet Union, from the Great October Revolution up to the very recent time, are inseparably linked with the name of A. F. Ioffe.

A. F. Ioffe was born on October 29, 1880, in the town of Romny in Ukraine. After graduating in 1902 from the Petersburg Technological Institute, A. F. worked for four years as a practical trainee at the University of Munich in the laboratory of W. C. Röntgen. It was there that A. F. Ioffe carried out his first scientific investigations, devoted to the study of elastic aftereffect in crystalline quartz and of the electrical conductivity of X-rayed crystals of rock salt. For the first of these works, in which a profound connection between the mechanical and electrical properties of crystals was revealed, the University of Munich awarded A. F. the degree of Doctor of Philosophy with highest distinction. In crystals of rock salt colored by X-ray irradiation, A. F. discovered the phenomenon of photoconductivity. These works marked the beginning of the general direction of A. F.' s many years of scientific activity, devoted chiefly to the physics of the solid state.

Having returned to Russia in 1906, A. F. Ioffe carried on intensive scientific work at the Petersburg Polytechnic Institute, lectured, and took an active part in the scientific and scientific-organizational activities of the Russian Physico-Chemical Society.

The atomicity of electricity, which followed already from Faraday' s laws of electrolysis but was not understood or accepted by nineteenth-century physics, and the atomicity of light, boldly placed by A. Einstein at the foundation of the theory of the photoelectric effect—

At that time these ideas were at the center of interest in physics. By studying elementary acts of the photoelectric effect from metallic dust particles in an electric field, A. F. confirmed the existence of the "elementary particle of electricity" —the electron, established by the American scientist R. Millikan and disputed by the Austrian physicist F. Ehrenhaft. A. F. also showed that the ejection of electrons by light does not occur uniformly, but according to a statistical law, at

various intervals of time. In this way A. F. Ioffe gave direct experimental proof of the discontinuous structure of light, of the existence of elementary particles of radiation—photons. Later, in 1924, A. F., together with his pupil N. I. Dobronravov, experimentally proved the existence of X-ray photons. These works played an important role in the development of modern quantum physics.

For his investigation of the elementary photoelectric effect and for proving the existence and measuring the magnitude of the magnetic field of cathode rays, Petersburg University awarded A. F. Ioffe in 1913 the academic degree of master of physics. Two years later, at the same university, he was awarded the academic degree of doctor of physics for new investigations of the elastic and electrical properties of quartz.

Already in these years, within the rather limited possibilities available to science in tsarist Russia, A. F. Ioffe' s remarkable talent was revealed not only as a researcher, but also as an organizer of science, a teacher, and an educator of young scientists. A. F. Ioffe' s lectures at the university and at the Polytechnic Institute attracted and gathered around him a group of talented young people —the first generation of his pupils.

A. F. Ioffe' s scientific, pedagogical, and organizational talent unfolded widely during the years of Soviet power. A. F. Ioffe belonged to that best part of the intelligentsia which, from the first days of the October Socialist Revolution, linked its fate with the fate of the people. Understanding the grand scale of the national-economic, scientific, and technical tasks facing the country, A. F. Ioffe directed his efforts toward creating a broad network of scientific-research institutes and laboratories, training cadres of scientists and engineers, and strengthening the connection between science and practice.

In 1918, in Petrograd, with the active participation of A. F. Ioffe, the Physico-Technical Institute (FTI) was created; it rapidly grew from a small department of the Roentgen Institute into a center of scientific and scientific-technical research. From 1918 to 1951 A. F. Ioffe was the permanent director of the FTI. A. F.' s brilliant mind, clarity of thought and ability to penetrate into the physical essence of phenomena, as well as the collective methods introduced by A. F. for conducting and discussing scientific research, helped attract talented young people to science, fostered the rapid scientific growth of his pupils, and shaped their scientific interests. During the years of the first five-year plans, on A. F. Ioffe's initiative, a broad network of physico-technical institutes and laboratories was created in the country. As individual laboratories of the Physico-Technical Institute developed and acquired independence in scientific activity, they were separated from the institute, and on their basis new scientific-research physics institutes were created. A. F. Ioffe assigned his best and most talented colleagues to work in the new institutes, as well as in those already existing, around whom new scientific groups were formed. Thus were created the Ukrainian FTI, the Ural FTI, the Dnepropetrovsk Institute of Metal Physics, the Electrophysical Institute, the Institute of Chemical Physics, the Siberian FTI, and others, as well as a large number of factory laboratories.

In 1919 A. F. organized at the Petrograd Polytechnic Institute a physico-mechanical faculty for training cadres of scientists capable of solving urgent technical problems at the level required by the newest physics. From 1919 to 1948 A. F. served as dean of this faculty, which trained thousands of leading scientists and engineers.

In 1932, on the initiative of A. F. Ioffe, N. I. Vavilov, and N. A. Maksimov, the first and only Agrophysical Institute in the world was established in Leningrad, devoted to applying the results and methods of research in contemporary physics to the problems of agriculture. From 1932 A. F. Ioffe headed this institute and, to the end of his life, remained its director and the guiding spirit of the research carried out there. During these years a new science arose and developed —agrophysics—of which A. F. Ioffe was one of the creators.

During the years of the Great Patriotic War, 1941-1945, A. F. headed important defense research and carried out extensive scientific-organizational work as vice-president of the Academy of Sciences of the USSR and academician-secretary of the Division of Physical and Mathematical Sciences of the USSR Academy of Sciences. In January 1942 A. F. Ioffe joined the Communist Party of the Soviet Union.

A. F. Ioffe was the organizer and chairman of a large number of all-Union and international congresses, meetings, and conferences on various questions of physics, which played an important role in the development of science. Beginning in 1925 he was editor of the principal physics journals in the USSR —the physics section of the *Journal of the Russian Physico-Chemical Society*, the *Journal of Experimental and Theoretical Physics*, the *Journal of Applied Physics*, the *Journal of Technical Physics*, and the journal *Physics of the Solid State*.

At the same time as this many-sided activity, A. F. Ioffe conducted intensive research work in the field of his principal scientific interests—the physics of the solid state. Until the thirties this work developed mainly in two directions: the physics of the mechanical properties of crystals and the physics of dielectrics. A. F. Ioffe and his collaborators elucidated the atomic nature of the plasticity of crystals, the causes of the strengthening of crystals under the action of mechanical forces, and the role of various factors determining the breaking strength and elastic limit of solids. These works gave rise to a whole series of investigations in the USSR and abroad and found broad practical application, in particular in the technology of cold working of metals.

The study of dielectrics was begun by A. F. Ioffe at a time when not only was detailed knowledge in this field lacking, but fundamental questions also remained unclear—first and foremost, the nature and laws of electrical conductivity in nonmetallic crystals. The works of A. F. and his school revealed the mechanism of the phenomena of conduction, polarization, and breakdown of dielectrics and led to the most important concept for solid-state physics: the connection between the electrical properties of nonmetallic crystals and disturbances of the periodic-

ity of the crystal lattice; to the elucidation of the role of ionization processes in dielectrics by electron impact and by Joule heat; and to the experimental study and construction of a theory of electrode phenomena, among other things. On the basis of these works new insulating materials were created.

Beginning in the thirties, A. F. concentrated the circle of his principal interests on the physics of semiconductors. In those years, practice knew only isolated, scattered applications of semiconductors—selenium, cuprous oxide, zincite, and others—the scale of which was negligible in comparison with the use of metals and dielectrics. The theory of semiconductors was in an embryonic state. A. F. Ioffe and his collaborators carried out many years of fundamental and wide-ranging investigations of physical processes in semiconductors—electrical conductivity in weak and strong fields, photoconductivity and the photoeffect, galvanomagnetic phenomena, contact processes, thermoelectricity, and others. At the same time, intensive work was under way on the application of semiconductors in technology—the creation of rectifiers, photocells, photoresistors, thermistors, thermoelements, refrigeration devices, and so on. A. F. Ioffe, together with A. V. Ioffe, was the first to reveal the fundamental role of electron-hole—

transitions in the electronics of semiconductor processes. These ideas served as the basis for the theory of contact phenomena and were, in essence, the cornerstone of the modern theory and practice of semiconductor devices. A. F. Ioffe initiated a new direction that connected the semiconductor properties of matter not with long-range order, but with short-range order in the structure, which led to a substantial change in the foundations of solid-state theory, as well as to an expansion of the possibilities for the purposeful technology of semiconductors with predetermined properties. A. F. was a pioneer in the field of the theory and practical applications of thermoelectric phenomena in semiconductors. A. F. Ioffe' s work on thermoelectricity, which proved the effectiveness of converting heat into electrical energy with the aid of semiconductors, opened to semiconductors a path into the large-scale power engineering of the future.

Simultaneously with the study of semiconductors, beginning in the 1930s A. F. Ioffe actively developed at the Leningrad Physico-Technical Institute research in the physics of the atomic nucleus and in the physics of polymers. Under the leadership of A. F. Ioffe, the Physico-Technical Institute in those years became a center of nuclear research in the USSR, which initiated the grand successes of Soviet nuclear physics and nuclear technology.

The study of the electrical-insulating properties of dielectric materials led to the development at the Physico-Technical Institute of polymer physics, and contributed to revealing the nature and laws of physical processes in high-molecular compounds, which was of particular importance for the synthetic-rubber industry.

From 1954 until the last day of his life, A. F. Ioffe headed the Institute of Semiconductors of the Academy of Sciences of the USSR.

A. F. Ioffe created a scientific school which, in the scale, significance, and breadth

of its scientific activity, has no equal in the history of physics. Among A. F. Ioffe' s pupils are such world-renowned scientists as Academicians A. P. Aleksandrov, A. I. Alikhanov, L. A. Artsimovich, P. L. Kapitsa, I. K. Kikoin, V. N. Kondrat' ev, B. P. Konstantinov, G. V. Kurdyumov, I. V. Kurchatov, L. D. Landau, P. I. Lukirsky, I. V. Obreimov, N. N. Semenov, Yu. B. Khariton; Corresponding Members of the Academy of Sciences of the USSR A. I. Alikhanyan, B. M. Vul, S. N. Zhurkov, P. P. Kobeko, Yu. B. Kobzarev, Ya. I. Frenkel, A. I. Shalnikov, and many others.

A. F. Ioffe' s scientific achievements received broad recognition in the Soviet Union and throughout the world. In 1918 he was elected a corresponding member, and in 1920 an academician. For research in the field of semiconductors, the results of which were set forth in A. F. Ioffe' s monograph *Semiconductors in Physics and Technology*, he was awarded the Stalin Prize, First Class. A. F. Ioffe was awarded the title of Hero of Socialist Labor, the title of Honored Scientist, and was decorated with two Orders of Lenin. A. F. was an honorary member of eight foreign academies, five universities, three physical societies, and vice-president of the International Union of Pure and Applied Physics.

Literally until the final hours of his life, the eighty-year-old scientist, the senior Soviet academician, did not cease his vigorous, fruitful creative scientific activity. The death of A. F. Ioffe is a grave, irreparable loss. His splendid life is an example of selfless service to science and to the Motherland.

Note: Figure translations are in progress. See original paper for figures.