PERSONALIA

DMITRIĬ VLADIMIROVICH SKOBEL'TSYN

(On the occasion of his seventieth birthday)

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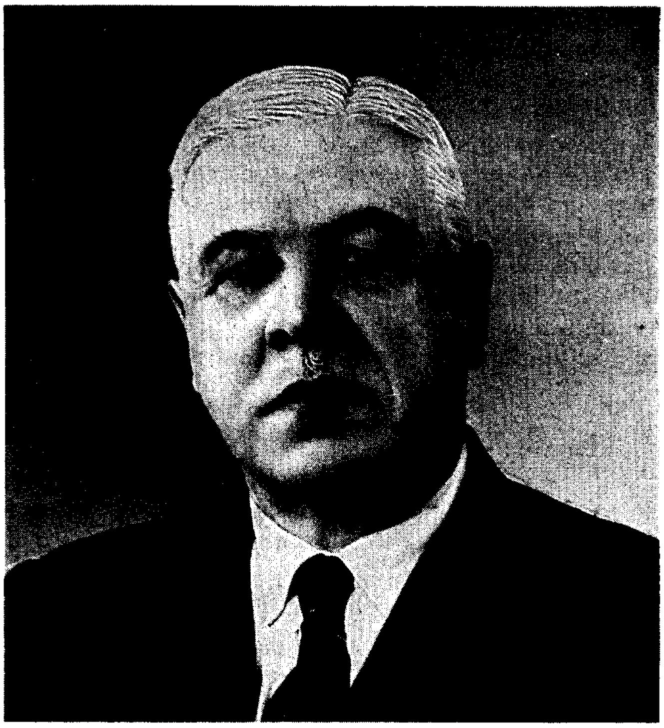

D. V. SKOBEL'TSYN was born in St. Petersburg (now Leningrad) on November 24, 1892, the son of a professor of physics. In 1915, after graduating from the physics-mathematics faculty of St. Petersburg University, he remained to work for the University's physics department, in training for a professorship. At the same time, he began his teaching career as an instructor at the Women's Medical Institute, and in 1916 he started to teach at the Polytechnical Institute as well. He served as a professor at that Institute until his removal from Leningrad to Moscow, and from 1925 onwards he also worked in the Leningrad Physico-technical Institute of the Commissariat of Heavy Industry (later the Academy of Sciences of the U.S.S.R.).

In 1938 Skobel'tsyn was transferred by the Presidium of the Academy of Sciences to the P. N. Lebedev Physics Institute of the Academy in Moscow, as director of the nuclear laboratory. In 1939 Skobel'tsyn was elected corresponding member, and in 1946 full member, of the Academy, while in 1957 he became a corresponding member of the French Academy of Sciences.

Skobel'tsyn's scientific work gathered momentum in the early twenties. One of the foremost questions in physics at that time was the quantum nature of radiation. This was the period when quantum mechanics was being evolved, and the experimental detection of the corpuscular properties of radiation was of great theoretical importance. In 1923, A. Compton haddiscovered the effect named after him and laid down the groundwork for the theory of scattering of short wave radiation from a free electron. It was of the utmost interest to study in detail the process of interaction of the highest frequency types of radiation then known—gamma rays of radioactive substances—with electrons.

That was what Skobel'tsyn attempted to do in his earliest investigations. With the use of the Wilson cloud chamber, which had been invented before the First World War, he was able to find a highly successful solution to the methodological aspect of this problem.

Before Skobel'tsyn's investigations, the cloud chamber had not been used for quantitative analysis of the interaction of relativistic particles with matter. In order to achieve this, Skobel'tsyn mounted his cloud chamber in a magnetic field. Charged particles traversing the chamber are deflected by the magnetic field; the radius of curvature of the track is determined by the strength of the magnetic field and the momentum of the particle. Thus through mounting the chamber in a magnetic field it is possible, by measuring the curvature of the track on the photograph, to determine the momentum of the particle.

There is no need to dwell on the importance which this method acquired in subsequent years. Suffice it to recall that it was the method used in discovering a number of elementary particles and in studying important processes occurring at high energies. By his use of this method, Skobel'tsyn was able not only to solve his original problem regarding the mechanism of the Compton effect, plus a number of related problems, but also, as we shall see below, to discover high-energy particles and groups of particles in cosmic rays.

Skobel'tsyn's experiments led to the unambiguous inference that there is quantitative, as well as qualitative agreement with the theory of the interaction of photons with free electrons posited by A. Compton.

The radiation cross-section turned out to be in agreement with the formula obtained by Klein and Nishina and I. E. Tamm, but in disagreement with the formula of Dirac and Gordon.

This cycle of Skobel'tsyn's investigations played a vital role in the verification of the theoretical concepts underlying the interaction of radiation quanta with particles, ushering in a new stage in the development of this branch of physics.

Subsequently Skobel'tsyn succeeded in utilizing the Compton effect in gamma-ray spectroscopy. This served as the basis for an extensive series of studies of beta and gamma-ray spectra and greatly furthered important scientific and theoretical investigations.

We now approach Skobel'tsyn's most significant work, central to his entire scientific activity—investigations of cosmic radiation. In analyzing, with his usual thoroughness, the series of cloud-chamber photographs he had obtained in investigating the Compton effect, Skobel'tsyn called attention to the tracks of particles not deflected by the magnetic field. He found that among the tracks of beta particles and electrons ejected by gamma rays, tracks strongly curved by the magnetic field, there are discernible straight tracks belonging to particles with energies exceeding 15 MeV. This clearly showed that the observed tracks could not be attributed to emission from radioactive substances.

Skobel'tsyn also evaluated the mean ionization produced in the atmosphere by the particles leaving these tracks. He found that the value of this ionization agreed with the ionization of air by cosmic rays. He therefore concluded that the straight tracks in the Wilson chamber were produced by charged cosmic-ray particles.

The existence of cosmic rays was discovered in 1912 because of their ability to ionize air. Until the work of Skobel'tsyn in 1927, however, the immediate cause of ionization had not been established. Physicists showed little interest in cosmic rays; cosmic radiation was studied primarily as a geophysical phenomenon.

Skobel'tsyn's discovery represented a breakthrough in this field of physics. It may be said that serious physical investigations of cosmic rays began only after he had demonstrated the presence of high-energy charged particles as one of the components in cosmic rays.

The next important forward step which aroused interest in cosmic rays was the establishment of the fact that in the region of high energies there occur phenomena with no analogues in the region of low energies, i.e., in the energy range of radioactive emission. The significant point is that cosmic-ray particles are often evinced in groups or, in modern terminology, in showers. Skobel'tsyn discovered cosmic-ray showers in 1929, as a result of analysis of the distribution of high-energy particles in Wilson chamber photographs.

Skobel'tsyn's remarkable observations were fully substantiated in subsequent experiments carried out by Anderson and others, using a similar technique, and more particularly by photographs of showers obtained by Blackett and Occhialini.

During the years immediately preceding the war, the main problems in cosmic-ray physics were two related questions: the existence and properties of the newly discovered particles, mesons, on the one hand, and the cascade theory of the electron-photon component on the other. Skobel'tsyn made significant contributions to both.

As regards the soft, i.e., easily absorbed, component of cosmic rays, the situation at that time was the following: there had been formulated, on the basis of Dirac's fundamental equations for electron and photon properties, a theory describing the production of brehmsstrahlung and formation of electron-positron pairs under the influence of photons. Both these processes should lead to the development of electron-photon cascades in matter. Comparison of this theory with experiment should test the applicability of the fundamental concepts of quantum electrodynamics to ultra-high-energy electrons and photons. Hence verification of the cascade theory was of paramount importance to physics as a whole.

Skobel'tsyn and his students undertook an extensive series of experimental studies of the properties of the soft component of cosmic rays and comparison of the experimental results with cascade theory. At the same time, under the direct stimulus of Skobel'tsyn's ideas, other physicists carried out theoretical studies aimed at further development of cascade theory, taking into account all the necessary variables.

After the interruption caused by the war, experimental and theoretical studies were continued, with the result that complete agreement was established between theory and experiment. Thus it was demonstrated that the fundamental concepts of quantum theory are valid for the description of the properties of electrons and photons of all energies, including the highest.

At the same time Skobel'tsyn carried out a profound analysis of the conditions of formation of the electron-photon component of cosmic rays and the question of equilibrium between the soft (i.e., electron-photon) and the penetrating component of cosmic rays. He established that the electrons from meson decay cannot explain the soft component observed in the atmosphere at altitudes above a few kilometers, and that this excess or "non-equilibrium" soft component must be attributed to a different source.

At his suggestion, experiments were undertaken aimed at determining the intensity of the electron component due to meson decay. It was found that the intensity of this component was lower than might be expected on the basis of the then current concepts on decay of mesons into one electron and one neutrino.

Skobel'tsyn also directed investigations in other branches of nuclear physics. Among these, mention should be made of comprehensive study of the process of electron-positron pair production in the gas filling a cloud chamber. This study showed that pair production as a result of interaction of photons with the electric field of nuclei of different elements is in perfect agreement with experiment.

Extensive investigations of cosmic rays at high altitudes were instituted under Skobel'tsyn's leadership. The value of stratospheric studies lies in the fact that at such high altitudes it is feasible to observe soft components that are absorbed before reaching mountain altitudes. Cognizant of the importance of measurements at high altitudes, Skobel'tsyn did his very best to encourage these valuable but difficult studies.

Investigations of cosmic rays in the stratosphere by means of balloons were carried out at the latitudes of Leningrad and Erevan and near the equator. As a result of these measurements, it was found that primary cosmic rays, at any rate in the main, are electrically charged particles.

Using the earth's magnetic field as a sort of selector, it proved feasible to sort the primary radiation according to energy. Analysis showed that primary cosmic particles with an energy of about 10^{10} eV are rapidly absorbed in the atmosphere. These absorption losses are much greater than losses due to ionization. Subsequent studies by Skobel'tsyn and his pupils showed that the reason for these great energy losses is the interaction of the primary particles with air nuclei.

During the war Skobel'tsyn, who had been evacuated with the Physics Institute of the Academy of Sciences to the city of Kazan', supervised and himself participated in a number of defense and applied research projects. At the same time he continued his theoretical studies of cosmic rays, concentrating on extensive air showers, which had been discovered shortly before the war by the French physicist Auger. His calculations, based on cascade theory, provided the basis for comparison of the calculated lateral distribution of particles in showers with the available experimental data. The comparison revealed a serious divergence: it appeared that cascade theory was incapable of describing the properties of extensive air showers.

In view of this, comprehensive research aimed at detailed study of extensive air showers was undertaken at Pamir at Skobel'tsyn's initiative and under his guidance. He organized the first expedition to the Pamir Mts. in 1944, even before the war's end. Since then, these expeditions have been repeated annually.

Skobel'tsyn proposed a new method for investigation of the lateral distribution of particles in air showers at large distances from the axis; this method called for the passage of several particles at each point of observation. Since this virtually excluded random coincidences, it was feasible from the outset to record showers with separations of about 1 kilometer between the counter arrays. This method also proved to have the highest transmission for the detection of the rare events of giant showers initiated by ultra-high energy particles. Before the end of the Forties, there were recorded at the Pamir station showers comprising over 10^8 electrons, that is, showers initiated by primary particles with an energy exceeding 10^{17} eV.

Later, again at Skobel'tsyn's suggestion and under his supervision, experiments were undertaken to elucidate the number-of-particle spectra of showers as well as measurements of the altitude distribution of showers. It was established that the observed altitude variation of showers differs markedly from the variation predicted by the electron-photon model, and it was shown that the composition of showers includes a significant number of penetrating nuclear-active particles.

The accumulated data led Skobel'tsyn and his students to the unambiguous conclusion that extensive air showers are not pure electron-photon showers, but are a result of a complex nuclear-cascade process. On the basis of their analysis they elaborated a new nuclear-cascade model for the initiation and development of extensive air showers; this model was generally accepted and proved to be highly useful for design of new experiments and for theoretical evaluation.

With a view to obtaining data on ultra-high-energy particles, Skobel'tsyn also advanced the idea that extensive air showers should be studied simultaneously at two levels. By observing the same shower at two altitudes or on the surface of the earth and underground, one can obtain valuable information on processes occurring at ultra-high energies. This idea is now being put to use in a special laboratory organized at Moscow State University for investigation of cosmic rays.

The study of ultra-high-energy particles by observations of extensive air showers carried out at Pamir under Skobel'tsyn's direction was closely associated with investigation of nuclear processes induced by particles of lower energies. Significant in these experiments was the determination of the increase with altitude in the number of showers observed under large thicknesses of lead. The presence of a thick lead absorber eliminated the possibility that these showers might be produced by high-energy electrons or photons. At the same time, the rapid change in the number of showers with altitude showed that they cannot be produced by penetrating muons either. Investigation of showers of this type by means of cloud chambers, ionization chambers and counter arrays revealed that both electrons and nuclear-active particles are comprised in such showers. Hence these showers were named electron-nuclear showers.

Obviously, electron-nuclear showers are fundamental to the nuclear-cascade processes that occur at very high particle energies. They lead to the formation of secondary nuclear-active particles in the atmosphere and production of the electron-photon component. Production of electron-nuclear showers is the principal mechanism of conversion of the primary cosmic ray energy, responsible for the subsequent appearance of all the components of cosmic radiation.

In addition to the above-mentioned studies of ultra-high-energy nuclear processes, there were continued under Skobel'tsyn's supervision extensive researches on cosmic rays at high altitudes. These led to the detection of an intense electron-photon component in the stratosphere. It was shown that this component cannot appear as a result of decay of muons in the atmosphere. Thus it was established that there must exist a different mechanism giving rise to the electron-photon component.

These investigations furnished the basis for analysis of the composition of cosmic radiation at high altitudes. It is significant that this analysis was carried out separately for different energy groups of the primaries by measurement of cosmic rays in the stratosphere at different latitudes. To obtain the requisite data, Skobel'tsyn organized a number of expeditions.

Under Skobel'tsyn's direction, too, the first experiments with rockets to study cosmic rays outside the atmosphere were undertaken in 1947. These investigations demonstrated that the electron-photon component is produced not only in the atmosphere but also outside it. These results were consistent with the properties of electron-nuclear showers observed at mountain stations. There was also detected an electron-photon component in electron-nuclear showers; this component appeared near the origin of the shower.

On the basis of the results obtained with rockets, in the stratosphere and at mountain altitudes it was inferred that if the electron-photon component appears as a result of disintegration of particles of some kind, the lifetime of these particles is less than 10^{-9} sec. This absolutely correct inference anticipated the discovery of neutral pions, made subsequently abroad.

A significant East-West asymmetry of primary cosmic radiation was observed by the 1949 equatorial expedition. It was shown that primary cosmic particles arrive mainly from the East, and that, consequently, most of them are positively charged. Results of numerous other experiments showed that the primary particles are atomic nuclei, principally protons. Study of these diverse phenomena required scientific investigation on a broad scale, and the credit for organizing extensive coordinated investigations belongs wholly to Skobel'tsyn.

The fundamental concepts underlying cosmic radiation were outlined by Skobel'tsyn in his now famous speech at the General Meeting of the Academy of Sciences of the U.S.S.R. in February 1950. On that date, the physics of cosmic rays became a branch of high-energy nuclear physics.

In 1951 Skobel'tsyn and his students were awarded a State Prize for their discovery and study of electron-nuclear showers and the nuclear cascade process. Their new concepts of the processes occurring in cosmic radiation were universally accepted both at home and abroad.

Subsequently, these concepts were developed further and refined. In particular, the men working under Skobel'tsyn paid great attention to the distribution of the primary particle's energy among the secondary particles in the energy region still inaccessible to experimenters using the most powerful accelerators.

It was established that collisions of high-energy particles with light nuclei are characterized by a high degree of elasticity. It was found that on the average an interacting nucleon loses only 30—40% of its energy to pions. This characteristic was significant in formulating the general picture of absorption in the atmosphere of the energy carried by cosmic rays.

Detailed investigation of extensive air showers led to a number of important inferences regarding nuclear collision in the region of high energies. In particular, it was shown that at energies of 10^{11}—10^{12} eV, the encounter of two nucleons frequently results in the formation of a cluster of excited nuclear matter (fireball, in modern parlance) which moves at a relatively low velocity and disintegrates into pions.

There is every reason to expect that further investigation of the interaction of high and ultra-high energy particles will soon lead to great discoveries and will further our understanding of the structure of elementary particles.

Moreover, study of extensive air showers has in recent years acquired considerable interest from the standpoint of determining the origin and composition of ultra-high-energy primary cosmic rays. Data now available give reason to think that at an energy of 10^{15}—10^{16} eV the composition of cosmic rays shifts in favor of preponderance of heavy nuclei.

The results of the various investigations mentioned above form a fundamental part of the science of cosmic rays and, as such, of the physics of high and ultra-high-energy processes.

Skobel'tsyn is the recognized head of a large and active school of Soviet physicists, specialists in the atomic nucleus, cosmic rays and accelerators.

Prior to the war, Skobel'tsyn published a monograph entitled "Cosmic Rays," which played a fundamental role in the education of scientists working in this field. In addition to thorough analysis of the experimental data, the book includes an exposition of the fundamental theory of interaction of charged particles with matter and the theory of deflection of primary cosmic ray particles in the earth's magnetic field. Although more than two decades have elapsed since its publication and the status of cosmic ray physics has radically altered in the meantime, this monograph is still an indispensable handbook for cosmic ray physicists.

Skobel'tsyn has been equally active as a teacher, organizer and public-spirited citizen. In 1940 he helped establish the Chair of the Atomic Nucleus in the Physics Department of Moscow State University. After the Second World War, he organized and for many years headed the Nuclear Physics Section of that Department, which is still one of the foremost centers for the training of nuclear physicists. During the period when Skobel'tsyn was head of the Section, a great number of highly qualified physicists were graduated from it.

In 1946, Skobel'tsyn organized the Scientific Research Institute of Nuclear Physics at Moscow State University; he served as its director for 15 years. Under his leadership, the Institute became a leading center in the field of nuclear research.

In 1951, following the death of Academician S. I. Vavilov, Skobel'tsyn became the director of the P. N. Lebedev Physics Institute, and is still successfully discharging this function. During the intervening years the Institute has more than tripled in size; its principal fields of investigation have shifted with the times; new trends have appeared and grown.

The staff of the Institute has carried out many outstanding studies, and the Institute is in many respects at the forefront of Soviet science.

Skobel'tsyn is also a prominent civic leader. He served as a deputy to the Supreme Soviet of the RSFSR, and was also elected repeatedly as deputy to the Supreme Soviet of the U.S.S.R. From 1946 to 1948 he was the U.S.S.R. atomic energy expert at the United Nations.

Skobel'tsyn's activity as a fighter for peace is well known. For many years he has been Chairman of the Committee on International Lenin Prizes for the Strengthening of Peace among Nations, and his name carries great influence in progressive circles. He was also among the initiators and is now one of the leaders of the Pugwash movement of scientists for peace. His ardent appeals for peace find a response not only in our country, but far beyond it borders.

In recognition of Skobel'tsyn's many accomplishments, a grateful Government has twice awarded to him the Order of Lenin and the Order of the Red Banner.

Translated by Mrs. Valentine S. Rosen