Sergeĭ Nikolaevich Vernov (on his seventieth birthday)

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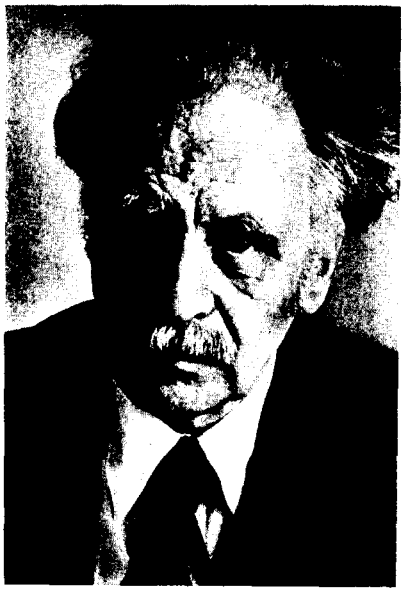
July 11, 1980 was the seventieth birthday of the prominent Soviet physicist and Academician Sergeĭ Nikolaevich Vernov. His name is invariably encountered in connection with practically all aspects of cosmic-ray physics research and the associated problems of elementary-particle theory, plasma phenomena, astrophysics, and geophysics.

Vernov was born in Sestroretsk. His father was a postal employee and his mother, a secondary-school mathematics teacher. After graduating from the Leningrad Polytechnic Institute in 1931, Vernov was accepted as a graduate student at the Radium Institute, and there began nearly a half-century of work in cosmic-ray research. At that time, the list of elementary particles that had been detected experimentally consisted only of the proton, electron, and photon. It was known concerning cosmic rays that they were of extraterrestrial origin and contained a complex mixture of particles with exceptionally high energies (as compared with radiation from radioactive substances). It was assumed that a substantial fraction of these particles was formed in the atmosphere under the action of some kind of primary component.

With the objective of minimizing the influence of the atmosphere and thereby coming closer to understanding of nature of the primary component, Vernov designed the world's first instruments for automatic high-altitude measurement of cosmic-ray fluxes with transmission of the data to the ground by radio. P. A. Molchanov's idea of the stratospheric radiosonde was used here. The first results that Vernov obtained with this procedure formed the basis for his Candidate's dissertation and were developed further. Steady improvement of the methods of investigation and the use of more and more powerful technical tools (geophysical rockets, artificial earth satellites, unmanned interplanetary probes) eventually become the focus of Vernov's work and led to a number of fundamental results.

In 1935, Vernov began his doctorate studies at the P. N. Lebedev Physics Institute of the Academy of Sciences of the USSR where his scientific style, which combines bold experiment with profound theoretical analysis, matured under the direction of S. I. Vavilov and D. V. Skobel'tsyn. During these years, Vernov implemented an extensive program of high-altitude cosmic-ray studies in which radiosondes were released at various geomagnetic latitudes, using the Earth's



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magnetic field as a gigantic spectrometer. Analysis of the variation of the cosmic-ray fluxes with latitude showed that the greater part of their energy is carried by charged particles, which are deflected by the magnetic field. The energy spectrum of the bulk of the cosmic radiation was obtained for the first time. Vernov defended his doctorate dissertation on the basis of these results, which are now classical.

After 1945, Vernov pushed development of stratospheric cosmic-ray studies on a broad front. He created the Stratospheric Station of the Physics Institute of the Academy of Sciences of the USSR (FIAN) and a special group at Moscow State University for this purpose. His object was final clarification of the nature of cosmic rays and the mechanisms by which they interact with matter. Unique instruments that had no analogs at that time were developed. They were used under Vernov's direct supervision to study the electron-photon, muon, and nuclear-active cosmic-ray components in the stratosphere. Having solved the problem of orienting instruments suspended from pilot balloons in a given direction (east or west), Vernov was able for the first time to obtain reliable measurements of the east-west asymmetry of the primary cosmic ray fluxes in the region of the geomagnetic equator. The

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sign of this asymmetry corresponded to a positive charge on the primary-component particles. Hence the conclusion that the bulk of the primary cosmic rays are of proton nature.

Analysis of the extensive material obtained in these experiments led to important conclusions as to the characteristics of the proton-matter interaction: comparatively low inelasticity and the production of an electron-photon component on decay of particles, which have lifetimes much smaller than 10^{-9} s (it was later shown that these particles are π^0-mesons).

Thus, the problem of establishing the nature of the primary cosmic radiation and the mechanisms that produce the secondary components was solved successfully in the course of many years of purposeful work by Vernov and his students. His results won wide international recognition and were confirmed repeatedly. In 1949, Vernov was awarded a First Degree USSR State Prize, and in 1953 he was elected a Corresponding Member of the Academy of Sciences of the USSR.

A unique installation for the study of superhigh-energy (10^{14}–10^{17} eV) cosmic rays was built late in the 1950's under Vernov's supervision at Moscow University. Instruments of various types of registration and precision analysis of extensive air showers produced by primary particles with gigantic energies were deployed over a large area. The system made it possible to study the characteristics of elementary-particle interactions at energies that are still inaccessible in particle accelerators. An important result obtained with the aid of this method was measurement of the energy spectrum of the primary cosmic rays in the range indicated. A break in the spectrum that probably corresponds to the transition from particles of galactic origin to the most energetic particles incoming from the Metagalaxy was detected at energies of $\sim 10^{15}$ eV. This result was registered as a Discovery. In the 1970's a gigantic new installation for registration of extensive air showers was built in Yakutiya under Vernov's general supervision; it covers an area of about 20 square kilometers and can be used to investigate particles with extremely high energies (10^{17}–10^{20} eV).

Along with study of the nature of cosmic rays and the mechanism of their interaction with matter, Vernov had a steady interest in problems relating to clarification of the conditions in cosmic space under which acceleration of protons and nuclei to gigantic energies becomes possible. An extensive network of ground stations for continuous registration of cosmic rays was created on the territory of the USSR with Vernov's support.

The balloon-sonde work was also developed further. Balloons have been released on a daily basis at various stations in the USSR since 1958 and in the Antarctic since 1963. The unique data obtained by this method have made it possible to detect gigantic cosmic-ray intensity bursts in the stratosphere following solar flares and have clarified details of the effects of the 11- and 22-year solar activity cycles on cosmic rays arriving from the Galaxy. The generation of low-energy cosmic rays in nearby interplanetary space was detected for the first time in these studies. A group of Vernov's co-workers was awarded a Lenin Prize in 1976 for a series of studies of cosmic rays in the stratosphere.

A most important element of the cosmic-ray research program was the conduct of experiments on artificial earth satellites (AES) and unmanned interplanetary probes (UIP) under Vernov's direction. A landmark discovery was made with the very first launchings of Soviet satellites: the Earth's outer radiation belt was detected. Study of the inner belt with the aid of the same satellites enabled Vernov and his co-workers to explain the nature of this zone (capture of the decay products of neutrons knocked out of the Earth's atmosphere by cosmic rays).

Vernov later directed a program of detailed studies of the radiation belts and the Earth's magnetosphere from "Elektron"-series AES. As early as 1968, these studies had illuminated the entire structure and dynamics of the radiation belts and led to the creation of a theory of their origin. The study of the Earth's radiation belts that Vernov directed has come to be recognized as an outstanding achievement of Soviet science. Vernov was awarded a Lenin Prize for this effort in 1960. He was elected an Academician in 1968.

Further elaboration of the above studies has made it possible to clarify several fundamental relationships of solar physics, the interplanetary medium, and the Earth's magnetosphere and ionosphere.

Vernov was one of the originators of a new trend in the study of high- and superhigh-energy primary cosmic rays on heavy AES, which had its beginnings in the Soviet Union.

Vernov's space research has been of great applied importance. Conditions in space (high vacuum, the presence of hot plasma, and, most important of all, high levels of radiation) give rise to specific difficulties in the design and operation of space vehicles. Vernov is one of the founders of space materials science. He also made a major contribution to the formulation and investigation of radiation-safety problems in manned spaceflight.

Over the fifty years of his scientific career, Vernov has attracted a large scientific following. Each stage of his work has given rise to scientific teams who have gone on to open up several new scientific trends and whose work has resulted in the solution of many important problems. Lenin Prizes have twice been awarded for the achievements of scientists of this school; they have also been recognized with four USSR State Prizes, a UkrSSR State Prize, and three Moscow State University Lomonosov Prizes.

The Scientific Research Institute of Nuclear Physics (NIIYaF) and the Division of Nuclear Physics of the Physics Faculty were created at Moscow University in 1946. D. V. Skobel'tsyn was the first director of the NIIYaF and head of the Division of Nuclear Physics. His first deputy and, since 1960, his successor in

these positions was S. N. Vernov. Under the direction of Skobel'tsyn and Vernov, the Moscow State University NIIYaF quickly grew into a first-class scientific organization, and the Division of Nuclear Physics became a center for the training of highly qualified scientific cadres. Many alumni of the Division are now Academicians and Corresponding Members of the Academy of Sciences of the USSR, Doctors of Sciences, and directors of major institutes and their subdivisions.

Vernov's scientific-organizational activity extends far beyond the confines of the Moscow State University NIIYaF. Since the time the Division of Nuclear Physics of the Academy of Sciences of the USSR was formed, he has been a member of the executive and Deputy Academician-Secretary of this Division; he heads the "Cosmic Rays" Scientific Council of the Academy of Sciences of the USSR. In these positions, he does a great deal of work on the planning of scientific research in the USSR. He constantly attends to the development of science in the Union and Autonomous Republics, particularly in Georgia, Armenia, Uzbekistan, and Yakutiya.

Vernov has been a member of the Communist Party of the USSR since 1952. He is actively engaged in community work as head of the Moscow Metropolitan and Regional Committee for the Protection of Peace. He was awarded the "For Protection of Peace" Medal in 1967.

Academician Vernov's outstanding scientific, teaching, and social achievements have won high recognition. He holds two Orders of Lenin, the Order of the October Revolution, two Orders of the Red Banner of Labor, the "Badge of Honor," and a medal with the inscription "For Meritorious Work, commemorating the 100-th Anniversary of the Birth of V. I. Lenin." Vernov is a Lenin and USSR State Prize Laureate.

Vernov's seventieth birthday finds him still in the untiring search for scientific novelty that has been so characteristic of him throughout his entire scientific career. We wish him many happy returns, good health, and active work.

Translated by R. W. Bowers