on the Compton effect, crystal conduction counters, scintillation counters, and the detection and measurement of gamma rays and their energies. In 1948 Hofstadter made the important discovery that thallium-activated sodium iodide, NaI(Tl), made an excellent scintillation counter, and in 1950, with John A. McIntyre, he showed how NaI(Tl) could be used as a spectrometer for measuring gamma ray energies. This crucial discovery by Hofstadter had far-reaching effects: The material has been in universal use as a gamma-ray spectrometer ever since, yielding important contributions to all branches of nuclear and high-energy physics and to astrophysics, as well as to medicine, biology, chemistry, geology and other fields. The material had such widespread use in spite of the fact that it is expensive and difficult to work with. In later years Hofstadter was to look back on his discovery of the linearity of response and high light output of NaI(Tl) as the most important contribution he made to science, in terms of its impact on a variety of fields.

In 1950 Hofstadter joined the faculty of Stanford at the urging of Felix Bloch and of Leonard Schiff, whom he had known earlier at Pennsylvania. He immediately embarked on a program to study elastic and inelastic scattering of high-energy electrons by nuclei using the Mark III linear electron accelerator at the High Energy Physics Laboratory. At first, when the Mark III was still under construction, the research was limited to a top energy of 200 MeV, but eventually the maximum energy reached its design value of 1 GeV. Hofstadter employed a type of magnetic spectrometer that was double-focusing (or point-to-point focusing) and built in a 180° configuration. As a result the spectrometers were quite large for the time: The largest one had a radius of curvature of 72 inches, was capable of analyzing 1-GeV/c electrons and weighed 140 tons.

These electron scattering studies, which continued over the next 20 years, explained how electric charge (and magnetism) is spread out within the volume of a nucleus, and they were extended to include the proton and the neutron as well. Even the neutron, which is overall electrically neutral, has a distribution of charge and magnetism within it. For the first time the proton and the neutron were shown to be nonpoint particles that therefore possessed structure—that is, they were somehow made up of other particles. He collected a number of the seminal papers in the field in an excellent book: *Electron Scattering and Nuclear and Nucleon Structure* (W. A. Benjamin, New York, 1963). For his extensive work in nuclear structure studies using the method of elastic and inelastic electron scattering, Hofstadter was awarded the Nobel Prize in Physics in 1961.

After 1968 Hofstadter and his colleague E. Barrie Hughes developed new detectors for high-energy physics. The "Crystal Ball," developed at Stanford and SLAC, was one outcome of this research. The Crystal Ball was a spherical array of over 900 sodium iodide detectors, all pointed at the common region where an electron beam collided with an opposing positron beam. This device uncovered fundamental new results in the spectrometry of new mesons containing charmed and bottom quarks. In 1970 Hofstadter introduced the idea of placing a large, high-energy gamma-ray detector on a satellite in Earth orbit to do gamma-ray astronomy—a field then in its infancy. Much of his effort in the last decade was devoted to helping design, build and test the Energetic Gamma Ray Experiment Telescope, one of the four instruments on board NASA's Gamma Ray Observatory. EGRET is sensitive to the highest-energy gamma rays, from roughly 20 MeV to 130 GeV. It uses electron–positron pair production in thin tantalum foils as the detection mechanism. The produced pair triggers plastic scintillators that, in turn, pulse on a set of digital spark chambers to image the pair trajectories. At the same time, energy analysis is accomplished by an array of NaI(Tl) scintillation crystals. GRO was successfully launched in April 1991, only a few months after Hofstadter's death.

Hofstadter had a lifelong interest in new applications of gamma-ray detectors to problems in medical physics. The early use of his sodium iodide detectors in the Auger camera was perhaps the first such example. The latest example was his idea that the intense, tunable synchrotron radiation produced at electron storage rings would provide a source of x rays uniquely suited to measuring the K edge of the iodine dyes used in coronary angiography. The first experiments on this concept were carried out at the SPEAR electron storage ring at the Stanford Linear Accelerator Center in 1980. The approach is based on the principle of iodine dichromography, in which two monochromatic x-ray beams, closely bracketing the K edge of iodine (33.17 keV), are used to acquire line-scan images.

At Stanford Hofstadter was appointed the Max H. Stein Professor of Physics in 1971, directed the High Energy Physics Laboratory (1967–72) and served on the Senate of the Academic Council (1971–72 and 1981–83). He retired in 1985 but was recalled to active duty every year after that until his death. He was an ardent supporter of Stanford athletic teams, and he enjoyed listening to music and spending time with his family on his ranch in northern California.

Hofstadter often taught introductory physics courses, and he was praised by students for the clarity of his lectures. He also used his simple teaching style effectively in upper division courses. His graduate students invariably found him to be helpful and caring. He was always concerned about his students' welfare, and they usually thought of him as a friend in addition to his role as their mentor.

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Dmitri V. Skobeltsyn

Academician Dmitri Vladimirovich Skobeltsyn, a prominent physicist of the 20th century and a pioneer of high-energy physics, died on 16 November 1990 in Moscow.

Skobeltsyn was born on 24 November 1892 in St. Petersburg, the son of a professor at the St. Petersburg Polytechnic Institute. After graduating from St. Petersburg University, he devoted himself to the pedagogical and scientific activities going on within the walls of the university and the polytechnic institute. In 1925 Skobeltsyn became a research fellow of the Leningrad Physicotechnical Institute.

His first experiments in Leningrad in 1923 were inspired by the discovery of the Compton effect. He continued them at Marie Curie's laboratory in Paris beginning in 1927.

Skobeltsyn was the first to advance the idea of using the registration of recoil electrons (Compton electrons) arising in a gas-filled Wilson cloud chamber. In his 1927 experiments, Skobeltsyn placed a Wilson chamber in a magnetic field and succeeded in determining the momenta of charged particles passing through the chamber. His investigations of the Compton effect of radium gamma rays enabled him to verify adequately and directly, by observation of the Compton electrons, the existence of the gamma quantum momenta. That observation contradicted the Compton and Dirac theories but agreed well with the Klein-Nishina-Tamm theory—the first rigorous result of the new field of quantum electrodynam-

Dmitri V. Skobeltsyn

ics. Thus Skobeltsyn's investigations of the energies and angular distributions of Compton electrons were some of the first reliable experimental bases for QED.

While investigating the Compton effect in 1927, Skobeltsyn observed the tracks of relativistic particles arriving in the cloud chamber from the atmosphere. The momentum of these relativistic particles was estimated to be larger than 20 MeV/c, and hence they could not have been the decay products of radioactive elements. He demonstrated that these particles often appear in a Wilson chamber as groups of a few particles. This was the first observation of a cosmic-ray shower phenomenon.

In 1928 at the London conference, Skobeltsyn reported discovering that the relativistic particles are a manifestation of cosmic rays in the atmosphere. He showed that the estimate of the ionization produced by these particles agreed with the then-available experimental data on geophysical ionization, the origin of which was then unknown. Thus, proceeding from his experiment, Skobeltsyn introduced into physics the modern notion of "cosmic rays," that is, particles of high energy from space.

In 1929 Skobeltsyn attempted to explain the simultaneous appearance in the Wilson chamber of several relativistic particles. His were the first discussions of the cascade multiplication processes underlying high-energy physics. A thorough understanding of these processes had to await the discovery of the positron and of pair production, and Skobeltsyn's work played a guiding part in the experiments that led to the former discovery (as well as the discoveries of the muon and, later, strange particles). His role as a pioneer and founder of high-energy physics was widely noted by, among others, Ernest Rutherford, Werner Heisenberg, Paul Dirac and Frédéric Joliot-Curie.

During the 1930s electromagnetic cascade theory was created to explain cascade multiplication of electrons, positrons and gamma quanta based on QED. Skobeltsyn was the first to use the energy conservation law to determine the quantitative relation between the number of particles at a maximum of the electromagnetic cascade and the energy of the primary particle inducing the cascade. This relation was decisive for the creation of the quantitative cascade theory and also formed the conceptual basis of a novel experimental technique, the ionization calorimeter or full-absorption spectrometer method.

In the late 1930s Skobeltsyn went to work at the Lebedev Physical Institute of the Soviet Academy of Sciences in Moscow. There he started a series of investigations into the extensive air showers that are the most striking manifestation of the cascade-producing power of superhigh-energy (10^5–10^{11} GeV) cosmic rays.

Experimental studies of different characteristics of extensive air showers by Skobeltsyn and his coworkers in the 1940s demonstrated that these showers develop not by the well-known electromagnetic cascade process, but by a nuclear cascade process accompanied by multiple hadronic generation. This discovery radically changed the existing concept of cosmic rays as particles of exclusively electromagnetic origin and underlies the modern conception of cosmic rays and their interactions with matter. More accurate investigations with accelerators in the succeeding decades confirmed the main characteristics of nuclear cascade processes at high and superhigh energies. The results of Skobeltsyn's school also were significant in the development of gamma-ray astronomy.

As the founder of the Institute of Nuclear Physics at Moscow State University and its director from 1946 to 1960, as well as the director of the Lebedev Institute from 1951 to 1973, Skobeltsyn greatly influenced his close disciples and many others by guiding their scientific work and generously sharing his ideas. His activities promoted the vigorous development of various trends in nuclear physics, including the creation of new accelerators, and the development of quantum electronics.

Skobeltsyn's interests ranged widely, from elementary particle physics to the intricate problems of general relativity and of the electrodynamics of continuous media. In each of these areas he left his mark, and his scientific papers and books contain comprehensive analyses of the problems in question, along with original approaches to their solution.

In the last years of his life Skobeltsyn took a lively interest in experiments in which narrow e^+e^- resonances were observed in collisions of relativistic nuclei. He felt a connection between these and his own experiments of the late 1930s in which he had observed the anomalous scattering of electrons emitted from radioactive sources. The results of the experiments on relativisitic nuclei held his keen interest until the last day of his life.

With Skobeltsyn's death, science has lost an eminent experimenter and theorist. His disciples have lost a wise, kind and considerate teacher. His friends and colleagues have lost a great man, one who was very friendly and sympathetic and who apprehended and valued not only science but also other lofty manifestations of the human soul.

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David Harker

David Harker died from complications due to heart disease and pneumonia on 27 February 1991, after a long illness. He was 84 years old.

Harker received his undergraduate degree in chemistry from the University of California, Berkeley, in 1928 and his doctorate in x-ray crystallography from Caltech in 1936, under the guidance of Linus Pauling. Harker's doctoral dissertation contained his first major contribution to the science of x-ray crystallography, an extension of A. Lindo Patterson's famous paper of 1934. Patterson had shown that the positions of the maxima of the Fourier series whose coefficients are the corrected intensities of the diffraction peaks obtained when x rays are scattered by a crystal coincide with the collection of the interatomic vectors in the crystals. What Harker saw was that, because atoms are related to one another by elements of crystallographic symmetry, scattering would produce peaks in the Patterson function only in certain planes or along certain lines determined by the crystallographic space group.

David Harker

This insight greatly simplified the interpretation of the Patterson function and facilitated the determination of crystal structures from x-ray diffraction data. This early contribution of Harker's influenced the development of x-ray crystallography for the next 50 years, and it still finds application in structural analysis, particularly of crystals containing a small number of heavy atoms.

Harker's second major contribution came in 1947 when he and John Kasper, working at the General Electric Research Laboratory at Schenectady, New York, discovered the first inequalities among the crystal structure factors. The structure factors are complex numbers, only the magnitudes of which can be routinely determined from the observed x-ray diffraction intensities. They are the key to the determination of crystal structures, because the positions of the maxima of the Fourier series whose coefficients are the structure factors (as distinct from the observed x-ray intensities) coincide with the atomic position vectors. The importance of the Harker–Kasper inequalities lies in the fact that they relate the complex structure factors to their magnitudes and in this way impose a limitation on their values. This result made possible the routine determination of the molecular structure of decaborane, $B_{10}H_{14}$, a problem that had previously defeated Harker's and Kasper's best efforts. More importantly, this work of Harker and Kasper served as the inspiration for the development of a major branch of x-ray crystallography, the so-called direct methods, which have made possible the routine determination of