Fedor L'vovich Shapiro (Obituary)

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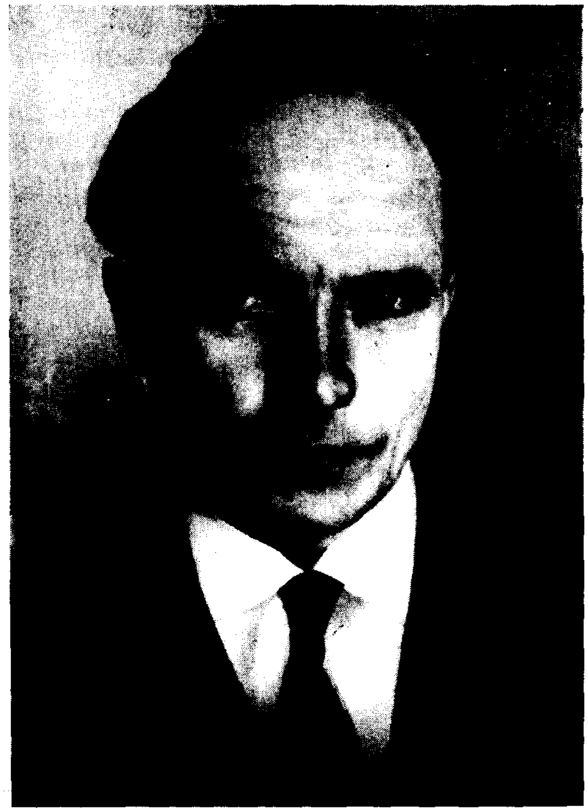
Fedor L'vovich Shapiro, a prominent Soviet physicist, a top expert on nuclear and neutron physics, Laureate of the USSR State Prize, Corresponding member of the USSR Academy of Sciences, Deputy Director of the Neutron Physics Laboratory of the Joint Institute of Nuclear Research, and a Professor at Moscow State University, died on January 30, 1973 after a long illness.

Shapiro was born on April 6, 1915, at Vitebsk. His path to a scientific career was no easy one, for his family could not afford to send him to the university immediately on his completion of school. He graduated from the Moscow Power-Engineering Technical School in 1935 and worked as a technician and later as an engineer. Enrolling in 1936 in the day division of the Moscow State University Physics Faculty, he successfully combined work and study. At the outbreak of the war he was completing his University program, and when the enemy approached Moscow, Shapiro enlisted in a Communist batallion of the Moscow Worker's Division and fought for the Motherland as commander of a reconnaissance-company detachment. He was decorated with the medal "For Bravery" for his combat performance. In December of 1941, he was severely wounded, suffering a shattered jaw, and a shell fragment remained embedded in his chest for the rest of his life. Treatment in hospitals went on for months. Shapiro was pronounced temporarily unfit for military service and he went to work in a planning agency, where he did national defense work.

In February 1945, Shapiro was accepted as a graduate student at the Physics Institute of the USSR Academy of Sciences, and the road to a real scientific career at last opened to him.

At this time, a broad program for the development of nuclear physics and the creation of an atomic-power industry was being implemented in the USSR. Research on reactor physics was being done in the Laboratory of the Atomic Nucleus at the Physics Institute, and Shapiro was soon involved in it. From that time, most of his scientific activity was related to neutron physics. "As Shapiro so aptly put it," wrote I. I. Gurevich and L. V. Tarasov in their preface to his book "The Physics of Low-Energy Neutrons," "'It would be difficult to name another field whose study would do so much to enrich the physical panorama.'" The brilliant career of F. L. Shapiro in science, which spanned less than 30 years, is a direct confirmation of this thought—his range of scientific interests was extraordinary wide.

He distinguished himself as a talented experimentor with superb theoretical background even in his very first experiments in reactor physics. He made substantial contributions to both theoretical and experimental research on a number of problems—resonant absorption of neutrons in thick layers of uranium, establishment of the various factors that determine thermal effects in reactors, etc. Some of the results were organized for his Candidate's thesis, which he defended brilliantly in



1949. He was awarded the "Badge of Honor" in 1953 for completing Government assignments.

Closely related to these studies was a long series of remarkable e in vestigations on a slowing-down-time spectrometer of Shapiro's design—the since famous one-hundred-ton lead cube. He proposed this spectrometer jointly with E. L. Feĭnberg and L. E. Lazareva. Shapiro found it necessary to reinforce the new method with experimental research and to develop, in collaboration with his students and colleagues, a theory of nonstationary neutron moderation. Shapiro also played a major role in studies of nonstationary diffusion and thermalization of neutrons.

The result was the creation of an original spectrometer with an exceptionally large transmission, a low gamma-background level, and a broad energy range. It was used to investigate radiative capture of neutrons in the nuclei of the elements that are of importance for reactor construction. Analysis of the results led to determination of the force function for p-neutrons as a function of the atomic weight of the nucleus, which is of great importance for development of an optical model of the nucleus. Later work by his colleagues and students proved that the possibilities of the spectrometric method are far from exhausted, despite 15 years of intensive use. Similar spectrometers are now being built in West Germany and India.

Among the studies carried out on the slowing-down-time spectrometer, special importance attaches to the work on the reactions of nuc-neutrons with light nuclei: helium-3, boron, and lithium.

Shapiro observed experimentally and then explained theoretically a deviation from the well-known Fermi law, according to which the absorption cross section is inversely proportional to neutron velocity. He showed on the basis of the most general considerations that Fermi's law is only a first approximation. Working from his own theory, Shapiro drew from the results of helium-3 experiments the fundamental conclusion that an excited state with spin 0 and positive parity exists in helium-4. This prediction was at first objected to by both experimenters and theoreticians. It was later brilliantly confirmed and has been generally accepted, although the path to recognition was not a short one. Development of the new trend in neutron spectrometry and the important results obtained in this field enabled Shapiro to defend his discertation successfully and win the degree of Doctor of Physicomathematical Sciences.

In 1959, Shapiro began work at the Joint Institute of Nuclear Research (at Dubna), where the Laboratory of Neutron Physics had just been organized and the first fast pulsed batch reactor (the IBR-1) was under construction. Shapiro's subsequent scientific and administative activity is inseparably associated with this laboratory. He had a strong influence on the formation and development of the Laboratory's young international staff and was the initiator of most of the new research and research directions that have made the Laboratory world-famous. The following project was the most important among the numerous studies of the Dubna period of his life.

Experiments with polarized particles are of great importance in neutron physics, as they are in nuclear physics in general. There are several methods of polarizing slow and fast neutrons. However, there were no adequate methods for a broad energy range extending from the tens into the hundreds of thousands of electron volts. Shapiro (jointly with Yu. V. Taran) proposed a new method for polarization of neutrons by filtering them through a polarized proton target—a method that completely covered the "white" energy range. Shapiro and his colleagues used this method to obtain the first high-intensity beam of resonant neutrons with polarization up to 70%. They subsequently performed important experiments with this beam to investigate the interaction of polarized neutrons with polarized nuclei. In particular, an experiment with a polarized deuteron target made possible experimental selection of one of two possible sets of amplitudes of neutron scattering on the deuteron.

Although the IBR-1 reactor was originally conceived of neutron-spectrometry work in nuclear physics, it also proved a highly effective tool for research in the physics of the condensed state of matter. Here a series of pioneering investigations are due to Shapiro and his colleagues. Working with Polish physicists, he found an experimental basis for the extremely productive neutron-diffraction method used in neutron-structural analysis—a method based not on measurement of the diffraction angle, but on measurement of neutron energy at a given diffraction angle.

Working independently of the foreign physicists, Shapiro proposed the so-called inverse-geometry method for investigation of inelastic interactions of slow neutrons and used it in a number of his papers. A series of interesting studies made with cold neutrons is also associated with his name. This work brought Shapiro, a specialist in the field of nuclear physics, wide recognition among specialists in solid-state physics.

The first system combining a pulsed reactor with an electron injector was designed and built under Shapiro's direct supervision. In this device, the electron source, together with a suitable target, serves as a pulsed photoneutron injector, and the IBR reactor becomes a pulsed subcritical breeder. With the other participants in the project, Shapiro was awarded a USSR State Prize in 1971 for the series of studies toward the creation and perfection of pulsed reactors.

Shapiro originated a whole avalanche of original ideas in other fields of nuclear physics: use of the asymmetry of the beta decay of nuclei formed by capture of polarized slow neutrons in the matter of a target to obtain information of value in nuclear and solid-state physics; a test of the general theory of relativity by use of the Mossbauer effect; a method of increasing intensity in time-of-flight measurements by scanning a spiral target, which serves as the neutron source, with the charged-particle beam (the so-called Shapiro method), and others. Some of these ideas were put into practice by Shapiro himself or by his colleagues, and others were implemented at the Soviet institutes or abroad. One of these original ideas that was put to work by Shapiro and his colleagues was the measurement of the magnetic moments of neutron resonances from their shifts in a magnetic field. The results of experiments for two resonances of erbium were published in 1972.

Shapiro devoted the last years of his life to a totally new field—the physics of ultracold neutrons (UCN). In 1968, Shapiro and his co-workers produced the first beam of UCN and confirmed experimentally that they are totally reflected at all angles of incidence, as predicted by Ya. B. Zel'dovich in 1959. In initiating these studies, Shapiro had in mind the accumulation of UCN for two fundamental experiments—detection of an electric dipole moment of the neutron and direct measurement of neutron lifetimes. However, extraction of the UCN from the reactor and transferring and storing them proved to be more difficult than had been expected, and extensive research was required in connection with this problem. The elegant and lucid experiments of Shapiro and his colleagues in this field won worldwide acclaim. He did not live to see the final realization of their objectives.

The development of UCN physics is still far from complete, but its importance is already clear. Their accumulation would make a reality of Fermi's venerable dream of the "neutron bottle" (as he called it). One wonders how much more excellent work might have come from Shapiro if fate had given him another 10 or 15 years.

Shapiro had many students. He did much to train staff for those of the country's institutes that formed the JINR. At very start of his scientific career, he supervised the installation of a nuclear physics workshop at Moscow State University. He later became a professor at the University, where, until recently, he gave lecture courses, most prominent among which was the course in neutron physics. Shapiro was the author of the "Atomic Physics" section of the widely familiar textbooks edited by G. S. Landsberg, and was an active member of the editorial staff of the journal "Uspekhi Fizicheskikh Nauk." He also directed much of the work of the Scientific Council on Nuclear Reactions in the USSR Academy of Sciences.

Shapiro was an unusually reserved person, a man who was always deeply concentrated on his thoughts. At the same time, he was never anything but amiable and always exceptionally attentive to anyone whom he engaged in any scientific discussion. The precision of his own usually laconic remarks and the throughness with which they were thought out were striking. He enjoyed exceptionally high authority, not only as a brilliant scientist, but also as a man. In science, his counsel was accepted without cavil or constraint. Fedor L'vovich was a distinguished man and mentor.

His wealth of ideas, absorption in science, energy, breadth of vision, and talent as an experimentor were always among Shapiro's traits, from the very beginning of his scientific career. His fame as a physicist increased with each passing year.

In 1968, Shapiro was elected a Corresponding Member of the USSR Academy of Sciences, and in 1971 he was awarded a second "Badge of Honor". His name is firmly established in physics. Those who worked with him and knew him will carry his glowing memory in their hearts.

Translated by R. W. Bowers