Evgeniĭ Konstanovich Zavoĭskiĭ (1907-1976)

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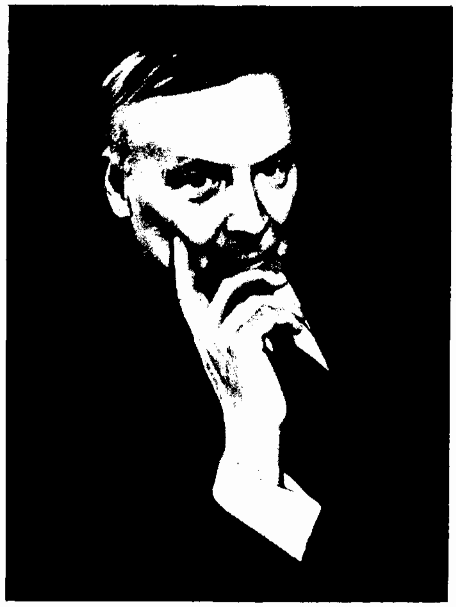
Usp. Fiz. Nauk 121, 735-736 (April 1977)

PACS numbers: 01.60.+q

The name of Evgeniĭ Konstanovich Zavoĭskiĭ has a place in the history of science because of his discovery of electron paramagnetic resonance and a whole series of brilliant studies in nuclear physics, controlled thermonuclear fusion, and physical electronics.

Zavoĭskiĭ was born at Kazan' into the family of a physician and studied and then worked at Kazan' University. Almost from his student years, the young physicist Zavoĭskiĭ nurtured the idea of using electromagnetic fields in the radio-frequency range to study the structure and properties of matter. Beginning in 1933, he performed exploratory experiments on the resonant absorption of radio-frequency fields by liquids and gases while at Kazan' University. In 1941, he became the first to use modulation of a constant magnetic field by an audio-frequency field in such experiments. In 1944, these experiments culminated in the discovery of a new fundamental phenomenon—electron paramagnetic resonance (EPR), which became the subject of his doctorate dissertation. Before defending his dissertation in 1945 and afterward, Zavoĭskiĭ studied briefly but very productively at the USSR Academy of Sciences Institute of Physical Problems at Moscow, where he had an opportunity to investigate the new effect at low (hydrogen and helium) temperatures. Returning to Kazan', Zavoĭskiĭ continued his investigation of EPR and, during 1945-1947, performed a series of extremely important experiments: for the first time, paramagnetic dispersion curves were recorded in the resonance range, the first results on EPR in single crystals of paramagnetic salts were obtained, and resonance lines corresponding to the multiple transitions $\Delta m = 2, 3$ were observed on Mn^{+2} compounds.

The importance of the discovery of EPR is difficult to overestimate. Since the end of the 1940's, EPR has been studied profoundly and from all aspects both at Kazan', where research in this area led to the formation of a strong scientific school of physicists who continued Zavoĭskiĭ's work, and in many other laboratories around the world. The range of objects of study soon broadened phenomenally, and it now includes practically all possible types of substances containing paramagnetic centers. Ionic crystals and glasses, free radicals and chelate compounds, metals and semiconductors, liquid solutions and gases, and, finally, biochemical objects of varying degrees of complexity—such is the range of substances that are now studied with the aid of EPR. Analysis of the fine and hyperfine structure of the spectra, the shapes and widths of the EPR lines, and the paramagnetic-relaxation parameters have made it possible to observe many extremely subtle details in the structure of matter. The nucleus spins of several isotopes have been determined with the aid of the hyperfine structure of EPR spectra. At the same time, the discovery of EPR was essentially the discovery of microwave spectroscopy, in which EPR will always remain the first and one of the fundamental chapters. Zavoĭskiĭ's pioneering work did much to stimulate the discovery of such effects as nuclear magnetic, ferromagnetic, antiferromagnetic, and nuclear quadrupole resonance.



Like any other major discovery, the discovery of EPR also influenced technological developments. It is sufficient to point to quantum paramagnetic amplifiers, the use of which has proven highly important in radio astronomy and space communications.

When research in atomic physics and nuclear energy began to develop in our country, Igor' Vasil'evich Kurchatov invited Zavoĭskiĭ to take part in it. More than 20 years of Zavoĭskiĭ's scientific career were associated with the Kurchatov Institute of Atomic Energy at Moscow. In 1952, he developed a new method of registration for ionizing-particle tracks—the scintillation-track chamber. This became possible as a result of a joint study with M. M. Butslov on the development of a unique device—a multichamber electron-optical converter sensitive to individual photons.

The new, extremely sensitive method of registering threshold images opened up completely new possibilities for research in nuclear physics, optical spectroscopy, astronomy, biology, plasma physics, and, finally, quantum electronics. As a true innovator and a great enthusiast for practical application of results, Zavoĭskiĭ did a great deal of promotional work for the new technique among Soviet physicists, astronomers, biologists, and other specialists. He personally participated in the first experimental use of the multichamber electron-optical converter on a telescope at the Crimean Astrophysical Observatory; he was the first to use the electron-optical method in plasma spectrochronography, in experiments done under the controlled thermonuclear fusion program.

In 1949, working closely with Zavoĭskiĭ, Butslov built plates into the electron-optical converter for the first time to obtain time scanning of the image. In the development of this project, Zavoĭskiĭ and his co-workers had laid the groundwork for a method of electron-optical chronography with time resolution of 10^{-11}–10^{-14} sec. The emission of a spark with a total duration of 10^{-10} sec and a front of 10^{-11} sec was registered experimentally for the first time, and an ionizing-particle spark counter with time resolution down to ten picoseconds was built. The electron-optical method of registering images of extremely low energy and short duration has been widely recognized and adopted. Every large telescope is now equipped with an electron-optical brightness intensifier, and electron-optical chronography provides the base for high-speed photography in the picosecond range and is one of the main tools used in the study of lasers with mode self-synchronization.

Another series of Zavoĭskiĭ's studies dating from the mid-1950's must be noted. During this period, he devised an original approach to the polarization of beams produced on charged-particle accelerators and to the design of polarization targets for nuclear-physics experiments.

From the end of the 1950's Zavoĭskiĭ devoted all of his energy to solution of the controlled thermonuclear fusion problem and the development of new methods for high-frequency and pulsed heating of plasma.

In 1958, Zavoĭskiĭ and his scientific staff discovered and then investigated in detail the phenomenon of magnetoacoustic resonance in plasma. Zavoĭskiĭ then concentrated his attention on the search for mechanisms of energy dissipation in plasma that are more effective than pair collisions. In 1961–1964, he and his co-workers discovered and studied the phenomenon of anomalous resistance and turbulent heating of plasma. It was shown that the energy of ordered motion (of waves propagating across the magnetic field and of the currents flowing along the magnetic fields) can be converted to thermal motion in collisionless mechanisms based on excitation of small-scale turbulence. This discovery aroused great interest and stimulated the rapid development of experimental and theoretical research on collective interactions and nonlinear processes in plasma. In 1968, Zavoĭskiĭ was the first to indicate the possibility of heating a dense plasma to thermonuclear temperatures with beams of relativistic electrons. This concept formed the basis of a completely new approach to the design of a controlled thermonuclear reactor, which is now being developed successfully by Zavoĭskiĭ's school at the Kurchatov Institute of Atomic Energy.

In 1972, a long spell of illness put Zavoĭskiĭ out of his accustomed working rhythm. However, though gravely ill, he continued his unwavering search for new pathways in science, completing a number of studies in EPR, solid-state physics, electron-optical chronography, and high-temperature superconductivity.

Zavoĭskiĭ devoted much time and effort to work in the USSR Academy of Sciences as a member of scientific councils and commissions and, during the last half-year of his life, as Editor-in-Chief of the Journal "Uspekhi Fizicheskikh Nauk."

Zavoĭskiĭ can rightfully be ranked among the classicists of modern physics. With his brilliant original talent as an experimentor and his profound physical intuition, he made weighty contributions to widely diversified and, it would appear, remotely related divisions of science. An untiring worker, a great optimist, and a charming and sincere individual, Zavoĭskiĭ created around himself a joyful atmosphere of willing service to science. He exemplified crystal clarity and adherence to principle, drove himself unsparingly, and dedicated himself fully to the solution of scientific and practical problems confronting Soviet scientists. Zavoĭskiĭ's accomplishments were held in high esteem by the Communist Party and the Soviet Government. He was named a Hero of Socialist Labor, awarded three Orders of Lenin, the Order of the Red Banner of Labor, and Lenin and State Prizes. The glowing memory of Evgeniĭ Konstantinovich Zavoĭskiĭ, a remarkable scientist and a man of high spiritual qualities, will remain forever in our hearts.

Translated by R. W. Bowers