PERSONALIA

Lev Andreevich Artsimovich (Obituary)

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Soviet and world science has sustained a grievous loss. On March 1, 1973, in the sixty-fifth year of his life, Academician Lev Andreevich Artsimovich, a member of the Presidium of the USSR Academy of Sciences, Academician-Secretary of the Division of General Physics and Astronomy of the Academy and a prominent physicist, succumbed after a long battle with heart disease.

Artsimovich was born in Moscow on February 25, 1909, into the family of a professor of statistics. In 1928 he was graduated from the physicomathematical department of the Belorussian State University at Minsk. His scientific career began at the Leningrad Physicotechnical Institute, which was then under the supervision of Academician A. F. Ioffe. At that time, the Physicotechnical Institute was foremost among the country's institutes of physics. The atmosphere of devotion to science and the scientific enthusiasm that were hallmarks of the scientific staff of the LPTI were exceptionally beneficial in shaping Artsimovich's scientific worldview.

Artsimovich's first studies, which he carried out in P. I. Lukirskiĭ's laboratory, pertained to the optics of x-rays; in particular, he investigated the difficult problem of total internal reflection in the x-ray region of the spectrum.

However, his interest soon turned to nuclear physics, a most intriguing and exciting field that was attracting the attention of physicists all over the world.

In 1936, Artsimovich collaborated with A. I. Alikhanov and A. I. Alikhan'yan in an experimental demonstration of the validity of energy and momentum conservation in positron annihilation. This study was the first direct experimental confirmation of the conservation of energy-momentum in an elementary act—a proposition that was doubted at the time, even by Niels Bohr.

However, the central team in Artsimovich's LPTI research, that in which his distinctive traits as an experimental physicist—lucidity of analysis and high reliability of the results obtained—were manifested most fully, was investigation of the interactions of fast electrons with matter. We should recall that our knowledge in this field was quite incomplete during those years. It is sufficient to note that experimental data on bremsstrahlung and the angular distribution of the scattered electrons were considered to be in disagreement with theory by two orders of magnitude. Detailed and highly accurate data obtained by Artsimovich in 1935—1940 on bremsstrahlung intensity and total energy losses as functions of the energy of the fast electrons made it possible to conclude that the predictions of quantum mechanics were clearly in agreement with the experimental data. This important result, which eliminated any doubt as to the validity of the basic theoretical premises, also opened the way to more precise later experiments.

During the Second World War, Artsimovich was engaged in research in electron optics with a bearing on the design of electron-optical systems.

In 1945, in a paper prepared jointly with I. Ya. Pomeranchuk, Artsimovich reported a detailed investigation of an important problem: the role of synchrotron radiation of the electrons in the betatron.

The rapid postwar ascendancy of nuclear physics in association with the development of nuclear power engineering and solution of national defense problems totally changed the scope and nature of physical research. Under these new conditions, which required rapid solution of a number of complex scientific and scientific-engineering problems, Artsimovich found himself at the head of an important applied trend—electromagnetic separation of isotopes. The problem was to transform a modest physical instrument, the mass spectrometer, into a reliable engineering facility that would be millions of times more productive. And, as is always the case in physics, the transition to new scales meant the appearance of new physical ideas and, with them, new difficulties. The staff of physicists working under

Artsimovich successfully solved the problem at hand, and the uses of electromagnetically separated isotopes in science and the national economy are still growing in scope and diversity.

At the end of 1950, Artsimovich was placed in charge of development of the new and fundamental scientific problem of controlled thermonuclear reactions. Working from Sakharov and Tamm's concept of the magnetically heat-insulated hot plasma, Artsimovich and his colleagues began research on high-power pulsed discharges in deuterium in a laboratory of comparatively modest capabilities. Forging ahead into an unexplored realm of physical phenomena, Artsimovich's staff scored his first successes as early as 1952: neutrons were produced in a gas discharge. Here it was the critical analysis carried through by Artsimovich that made it possible to avoid the extremely attractive but erroneous conclusion that these neutrons were of thermonuclear origin. Thus began a long period of physical research on the hot plasma and solution of the extremely difficult problem of confining it. All of these studies were carried out under the supervision and with the direct participation of Artsimovich.

Under Artsimovich, the division carried out pioneering work in the problem of controlled thermonuclear fusion: the discovery and investigation of the plasma focus (N. V. Filippov et al.), experimental proof of the existence of the plasma flute instability and the stabilizing action of the "magnetic well" (experiments of M. S. Ioffe et al. with magnetic mirror bottles), acquisition of macroscopically stable high-temperature plasma columns in the "Tokamak" closed toroidal systems and the conduct of a physical thermonuclear reaction in these systems. Artsimovich made a major personal contribution to these last studies, not only as a supervisor, but also as a direct participant in them. In particular, he worked in the development of a method for determining the temperature of the plasma ionic component. In his analysis of the experimental material, Artsimovich derived semiempirical formulas for the transfer coefficients and temperature of the plasma in Tokamaks that are important for prognosis.

To his last hour, Artsimovich retained his investigator's spirit, freshness of perception, and thirst for knowledge. Though ill, he would inquire into the details of an experiment, subject the results to a punctilious analysis, and advance original hypothesis for their interpretation.

His impressive erudition in all the subtleties of the problem of controlled nuclear fusion, his soundness of judgement and at times merciless criticism of research results, and his exceptional physical instinct made Artsimovich an acknowledged world authority in this problem of the century. He did not confine himself to purely scientific and scientific-administrative activity in the problem of controlled thermonuclear fusion, but also gave a great deal of attention to the business of mobilizing fresh scientific forces for work on the problem, with no small assistance from his literary brilliance and lecturing talent. His monograph "Controlled Thermonuclear Reactions" and his numerous lecture courses on plasma physics and controlled thermonuclear fusion, which he presented not only in our country, but also in Great Britain, France, and the USA, are widely known.

His unique combination of a brilliant intellect with a warm personality, his scientific and human ardor, his search for practical results in science with love for its intrinsic beauty, his scintillating wit and subtle turn of mind, his encyclopedic education and insatiable interest in everyday life—all of these attributes made Artsimovich a natural center of attraction for numerous students, colleagues, and friends.

While engaged in specific physical investigations, Artsimovich took a deep interest in the general trend of scientific development and gave much thought to the place of science in the rapidly changing contemporary world and to the principles on which it should be organized and guided. There is a hint of sadness in his paper "The Physics of Our Times" ["Novyĭ Mir," No. 1 (1967)] as he writes about one of the negative aspects of the industrialization of physics: "A few years after beginning his scientific career, the capable and energetic physicist is pushed up the steps of the organizational ladder and becomes the director of a specific group or laboratory. Here his workload of purely organizational activity increases rapidly and dissolves into the multitude of little operations of administrative nature that are necessary to ensure normal conditions for prosecution of the scientific work. The fraction of his time taken up by such functions increases with each passing year, and the opportunities for direct involvement in experimental work are increasingly limited. Thus does the experimental physicist alienate himself from the experiment."

Posing the question as to "whether we should deploy our forces evenly for an offensive all along the vast front of modern natural science," Artsimovich phrased a kind of valedictory to our scientific youth: "Much experience has now been accumulated in international competition in the basic trends of physical science, and we have established the conditions under which we may reasonably hope to make an honorable contribution to the world's production of first-class scientific information. Here the most important precept is not to follow on the heels of our powerful rival along a path of his choosing. It is difficult to pass the car ahead of us on a narrow road. Success will come only if we choose the path that is the right one for us.

"Many different paths open at once before talented people on the virgin territory of science. Like roads in mountain passes, they are not straight; one cannot see far ahead, and something new may appear where it is least expected. If you follow someone else, even right on his heels, you will never experience the joy of first discovery; that will go to those with the lead, no matter how slight it may be."

Of the two classes of physical problems whose solutions, to use the language of the article cited above, must answer the questions "How is this explained?" and "How can this be done?," Artsimovich dealt directly with the latter class toward the end of his scientific career. However, he also devoted much energy to the development of physical problems of fundamental scientific importance. Artsimovich served continuously from 1957 as Academician-Secretary of the Division of General Physics and Astronomy of the USSR Academy of Sciences. Attaching great importance to the two "extreme" trends in physical science—elementary-particle physics and astrophysics ("It is here that we may expect a revolution that will shake scientific ideology to its foundations")—he did much to organize and develop Soviet scientific research in physics and astronomy.

Artsimovich began his teaching activities at an early date and gave much effort to the preparation and training of young physicists. He lectured at the Leningrad State University, the Moscow Engineering Physics Institute, and Moscow State University.

Artsimovich's scientific excellence was held in high esteem by the community and the government. He was elected a corresponding member of the USSR Academy of Sciences in 1946 and an active member in 1953. Artsimovich was a Hero of Socialist Labor, held a number of Orders of the Soviet Union, and was a Lenin and State Prize Laureate.

Artsimovich was an ardent proponent of international collaboration between scientists in solution of the most significant scientific problems. Clearly recognizing the responsibility of the world scientific community in a nuclear century, he took an active part in the Pugwash movement as a prominent member of its International Committee.

Artsimovich lived brilliantly, leaving his mark clearly chiselled into one of the cornerstones of Twentieth-Century physics—the problem of controlled thermonuclear fusion.

Perhaps more than anyone else, he recognized at the start not only the magnificence of a solution to this problem, but also the limitless difficulties on the path to that solution, as reflected in his aphorism: "The hope for a quick solution to the problem of controlled thermonuclear fusion is like the hope of a sinner of reaching Paradise without passing through Purgatory." He himself traveled far along this thorny path, and the acknowledged success of the "Tokamak" program was his crowning scientific achievement.

The brilliant mind and irresistible personal charm of Lev Andreevich Artsimovich will always be remembered by his friends and colleagues and all others who had the opportunity to associate with him.

Translated by R. W. Bowers

ERRATUM

Article by F. V. Bunkin et al., "Interaction of Intense Optical Radiation with Free Electrons (Nonrelativistic Case)," Vol. 15, No. 4, p. 416.

In the calculation of the coefficient of light absorption by an electron beam propagating along the electric-field polarization vector, the averaging over the phase shift was carried out in error (formula (2.31) and Fig. 2a). In the general case this averaging is quite complicated. The weak-field approximation $\zeta \ll 1$ (first formula of (2.30)) has been correctly treated in the review. For the strong-field asymptotic form at $\zeta \gg 1$ we obtain in place of (2.31) the result

$$\alpha = \frac{16\pi Z^2 e^3 N_i N_e \omega}{c E_0^3} \left\{ \frac{1}{3} + 4\bar{L} \ln \left[\frac{2\zeta}{(Ze^2\omega/mv_0^3)^{1/3}} \right] \right\},$$

Where $\bar{L}$ is the Coulomb logarithm $L(\psi)$ averaged over the phase ψ. It follows from this expression that in a strong field the absorption coefficient is positive, whereas in a weak field it is negative. The absorption coefficient reverses sign (in the region $\zeta \sim 1$), having at least two extrema, and decreases like E_0^{-3}) at $\zeta \gg 1$.

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