«FAUST CURVE WITHOUT MEPHISTOPHELES IMPURITIES»

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ABSTRACT

Being a man of encyclopedic knowledge, a brilliant theoretician and experimenter, academician Sergey Vavilov has received international recognition for his work in the field of luminescence («cold light»), physical optics, became a founder of a branch of science, called microoptics. In the arsenal of his developments there are rangefinders and stereo telescopes, means of aerial photography and optical control, masking of warships and lighting of submarines, he headed for many years at the same time State Optical Institute and Physical Institute of the USSR Academy of Sciences. The last six years of life he headed the USSR Academy of Sciences, played a huge role in post-war reform of Soviet science.

The article is devoted to the 125th anniversary of the birth of the scientist, organizer and popularizer of science and public figure.

Keywords: physics, optics, Sergey Vavilov, luminescence, science, history, academy.

Background. *Paying tribute to this man, the scientific community is not always inclined to remember the fact that the ideas of S. I. Vavilov determined the emergence of a number of discoveries that have received international recognition.*

A typical example: in the 1930s, the theory of radiation of Vavilov-Cherenkov marked the beginning of a new direction in the study of the nature of elementary particles of high energies. Subsequent works by I. M. Frank and I. E. Tamm led to awarding them and P. A. Cherenkov Nobel Prize, but Vavilov, alas, at that time was no longer alive.

Again Sergey Vavilov gave an impetus to the practical implementation of half-forgotten idea of Albert Einstein on strengthening radiation with the same radiation. And when so famous now laser systems were created (after Vavilov's death), Soviet physicists N. G. Basov and A. I. Prokhorov were also awarded with Nobel Prize.

It is impossible to ignore another fact: the time of his presidency at the Academy of Sciences of the USSR fell on very hard in all respects 1945–1950 years. War-ravaged economy, erased from the face of the earth towns and villages demanded attention in the first place, but mobilization of science was required to the forefront of nuclear physics, electronics, new materials, manufacturing technologies and vehicles. Science had moved maximally closer to the life. This situation, regardless of the fact that it might seem strange, did not contradict philosophy, academic views and outlook of Vavilov-theorist.

In this regard, his interpretation of philosophical sense of Goethe's «Faust» was illustrative, that was the work to which the scientist periodically returned in his comments on the pages of the book (in German) and in two notebooks, its annexes, which accompanied Vavilov for more than thirty years. He tries to identify the difference between bookish and «real» Faust, and the idea of the role and purpose of the scientist itches constantly.

Goethe's image of Faust does not seem «real» as the hero of the drama is unfaithful to science, rushes into the vortex of pleasure, false values and loses «degree of peace of mind» and «contemplation», necessary to scientists. To prove this thesis Vavilov draws a diagram where on x-axis he puts actions, duration in their sequence, and on the ordinate axis he puts the degree of balance of mind and contemplation. Above the diagram, the inscription: «Faust curve» «en naturel» without impurities of Mephistopheles». This curve initially rises several times, but then fades away, symbolizing the defection of former goals and values.

Returning again to the question on what a real scientist should be, Sergey Ivanovich concludes: «Like Wagner. Not like Faust». That is, preference is attributed to Wagner – scientist-craftsman, promoting science and not yielding to magic. The final conclusion summarizes not only the plot of a literary masterpiece: «Faust is a tragedy about action, not about ideas, not about the scientist, but the person. Science is discarded from the beginning. Instead of it is there is a magic as a simple and shameless means to seize large. Almost theft».

It is hardly possible to consider these words of Vavilov as an unconditional philosophical credo of the great scientist and citizen. However, they have doubtless and direct relationship to the content and meaning of his life.

Objective. *The objective of the author is to investigate life and work of a prominent Russian scientist Sergey Vavilov.*

Methods. *The author uses general scientific methods, historical-retrospective analysis.*

Results.

From commerce to luminescence

Academician Sergey Vavilov was born in Moscow on March 24 (March 12 Old Style) 1891 in a family of merchants. After graduating from the Commercial College, having passed an additional exam in Latin language, he in 1909 entered the Mathematics Department of Physics and Mathematics Faculty of Moscow University. From the second year the student under the guidance of Professor P. N. Lebedev, and after his death in 1912 – of professor P. P. Lazarev began to regularly perform research. In 1913, in the Journal of Russian Physico-Chemical Society he published a review article «Photometry of colored sources», and a year later he edited the second article «On kinetics of thermal fading of colors», for which the Society of Naturalists, Anthropology and Ethnography at the Moscow University awarded him a gold medal.

Since 1914, Vavilov after graduating served four years in the army, participating in the hostilities on the Western and North-Western fronts – first as ordinary, then as junior non-commissioned officer in the Battalion, Road unit and army radio communication system. In wartime conditions, he performed experimental and theoretical study to determine the frequency of the antenna vibrations and developed a simple and reliable method for direction finding of unknown enemy radio stations by the relative strength of the signal received at the same time by several other radio stations. After experimental verification of the proposed method in October 1916, he drafted a guide with recommendations on the application of the method of direction finding in the army, and wrote the corresponding article. But the manuscript was lost. It was found and published only in 1952 after the death of a scientist.

Since 1918, Vavilov taught physics at MSU. First he conducted workshops, and from 1920 taught special courses. In 1929 he became professor and head of the department of general physics. At the same time as the head of the department of physical optics he conducted research on the nature of light under the direction of Lazarev, who at the time was in charge of the physical laboratories of the People's Commissariat of health. These laboratories were transformed in 1920 into the Institute of Physics and Biophysics.

Wanting to detect quantum properties, Sergey Ivanovich studied the absorption coefficient of light with a very strong change in its brightness. Then he started experiments in luminescence (weak self-illumination) to determine dependence of its intensity on the wavelength of excitation light. In his doctoral dissertation he found that the yield of photochemical reaction does not depend on the length of such a wave. Later Vavilov investigated a similar dependence of the quantum efficiency of luminescence.

In the early 1920s he published his first scientific popular works «The effects of the Light» and «Sunlight and life of the Earth». He tried to describe in intelligible form but scientifically the latest achievements of science of physics concerning optical properties of molecules and quantum phenomena, photoelectric effect, photochemistry and photoluminescence.

In the years 1923–1924 he carried out work to determine the absolute value of the luminescence yield and in the years 1924–1925 he studied light cessation with increasing concentration of the solution. In 1925, together with V. L. Levshin as a result of experiments, a decrease in the absorption coefficient of uranium glass with high light intensity was found. This effect of Vavilov-Levshin was the basis of nonlinear optics. Currently, it is used as an optical shutter in pulsed solid-state lasers, which are cells with a specially selected fluid, which becomes transparent to the laser beam when reaching a certain power.

In 1926 Vavilov in laboratories of the German specialist in the field of luminescence P. Pringsheim (University of Berlin) performed several experiments on polarization properties of prolonged luminescence of molecules. Returning to Moscow, he continued his studies. He found that the quantum yield of luminescence of bright fluorescent substances

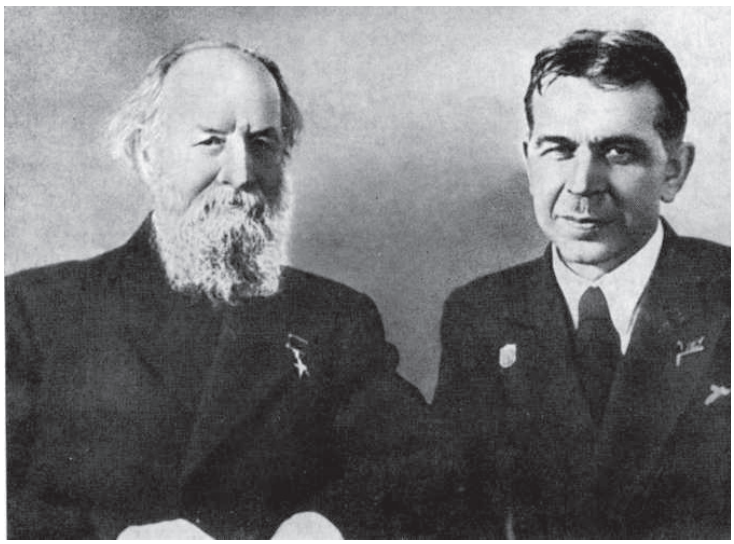
transform into the light more than 70% of the absorbed energy, remains constant over a wide wavelength range of the exciting light and sharply drops when the length of such waves exceeds the wavelength of the luminescence spectrum. This property, known as Vavilov's law, confirmed the manifestation of quantum properties of light, summarized and corrected Stokes' law.

In 1927, Vavilov published a non-fiction work «The Eye and the Sun», which went through five editions during his lifetime, and to the 200th anniversary of the death of Isaac Newton he translated into Russian and published the book «Optics» of English scientist, wrote introduction and research comments.

In 1928–1931 years Vavilov investigated termination of luminescence of solutions by foreign admixtures. Studying the causes of a decrease in the luminescence yield, he developed the theory of migration of excitation energy in solutions quantitatively explaining such phenomena. In 1931 he was elected a corresponding member of the Academy of Sciences of the USSR, and he, along with the new status acquired additional responsibilities.

Bright light silence

In 1932, Vavilov was appointed Deputy Director for Research of the State Optical Institute (GOI), which was a research center of optical-mechanical industry in the country, played a leading role in lighting engineering, optical engineering,



Academicians A. N. Krylov and S. I. Vavilov during the anniversary session of the USSR Academy of Sciences.

S. I. Vavilov in the army (on the right in the bottom row), 1915.

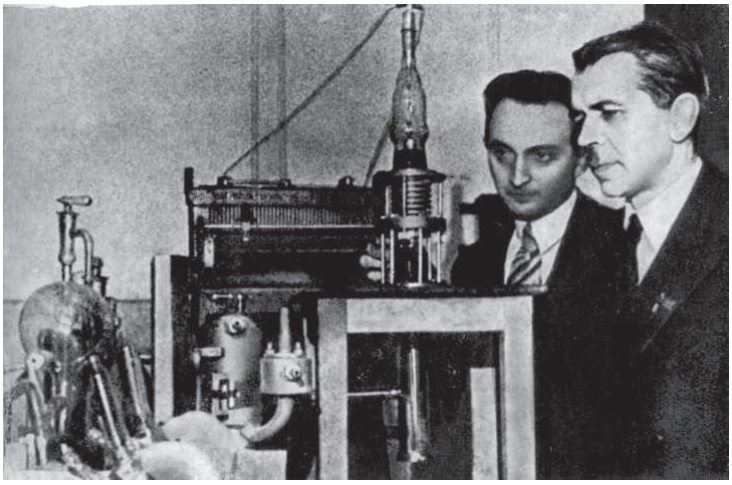
photochemistry, photography, manufacture and polishing of optical glass, optical pyrometry. Continuing to lead the former topics in his laboratory of luminescence analysis, Sergey Ivanovich strongly promoted deployment of works on creation of electron microscopes, unmasking of objects on snow, physiological optics, study of stratosphere.

The same year, Vavilov became an academician and director of Physical Institute of the USSR Academy of Sciences (FIAN). Here, under his leadership, a graduate student P. A. Cherenkov made in 1934 a discovery, found the glow of pure liquids, caused by the movement of electrons in them at a speed exceeding the phase speed of light in the medium under the influence of gamma and beta radiation of radioactive substances. Radiation Theory of Vavilov-Cerenkov later was developed by I. M. Frank and I. E. Tamm. Thanks to it speed of elementary particles of high energy was defined, their nature was revealed, the antiproton was discovered. The observed effect is used in astrophysics, in solving the problems of controlled thermonuclear reactions, in special spectrometers to lock the beams speed in the work of accelerators, as well as in calculating instrument used in space technology. In 1958, Tamm, Frank, and Cherenkov for the discovery and interpretation of this effect were awarded the Nobel Prize (according to provisions of the Nobel Prize it can be awarded to acting scientists, but Vavilov had passed away).

Several studies carried out in cooperation with V. L. Levshin were devoted to the study of luminescence polarization, allowed to come to the practical solution of the problem of the nature of elementary radiator and to achieve technology of production of more durable and efficient than incandescent lamps, fluorescent sources of artificial electric light. «Daylight» lamps became widely used. In the prewar years, together with the students the academician offered the most advanced methods of luminescence analysis and laid the foundation of the ultraviolet and fluorescent microscopy.

Vavilov combined many duties, considered it his duty to popularize science and its heroes. He was chief editor of the journals «Nature» and «Science and Life», a member of the editorial board of the journal «Advances of Physical Sciences», «Technical Encyclopedia», led commissions of the USSR Academy of Sciences on the history and the publication of popular science literature. He founded the series of books «Results and problems of modern science», «Classics of Science», «Biographies», «Memoirs», «Literary Monuments». In works devoted to scientific heritage of M. V. Lomonosov, P. N. Lebedev, I. Newton, G. Galileo, H. Huygens, M. Faraday, L. Euler and other scientists, he paid special attention to continuity in the development of ideas, concepts, theories, and philosophies.

The wide field of activity, the highest knowledge, the talent of scientific prediction made figure of



S. I. Vavilov in the laboratory of GOI, on the left — Z. M. Sverdlov (about 1946).

academician more noticeable. In 1938 he was elected deputy of the Supreme Soviet of the RSFSR [Russia within the Soviet Union].

During the war Vavilov, being both the director of FIAN, evacuated from Moscow to Kazan, and the scientific director of GOI, evacuated from Leningrad to Yoshkar-Ola, theoretically summarized experimental results of research, completed construction of the theory of migration of luminescence energy in solutions. Under his leadership, new models of rangefinders were created for the army, as well as stereotelescopes, lenses for aerial photography, means of optical control of camouflage coatings, methods of camouflage of warships, flight glasses for military aviators, glowing fluorescent compounds, examples of fluorescent lamps for submarines, new glass compositions, etc. In 1943 he was appointed commissioner of the USSR State Defense Committee.

In 1942, when it was a topical question to save electrical energy, the scientist gave a lecture «On the cold light», which was published as a leaflet. Subsequently, it was reprinted under the title «On the warm and cold light». The ambiguity of the topic for him seems obvious. To it as an epigraph words of favorite lyrics of Athanasius Fet, favored by Vavilov, are suitable:

All night I see to flicker,
What shines powerfully and gently,
And at this bright silence
I will look very diligently ...

To the 300th anniversary of the birth of great physicist, progenitor of the laws of mechanics he wrote a solid scientific and biographical book «Isaac Newton». Moreover, we note, this was done in 1943, in the midst of war, with an abundance of all sorts of other things. However, at the same time Vavilov wrote a brilliant monograph «Galileo and the history of optics», intended for the anniversary collection of works dedicated to Galileo.

In 1945 Vavilov was elected president of the Academy of Sciences of the USSR and Chairman of the Council on coordination of activities of the Union Republics Academy of Sciences. During this period the country faced enormous tasks of rebuilding war-ravaged national economy, industrial and residential construction, development of new research areas (studies of atomic nucleus, outer space). At the initiative of Vavilov, who had just taken over as head of the Academy, some projects were started, comprising construction of a new building of FIAN, educational and scientific complex of Moscow State University on Lenin Hills, institutes of organic chemistry, metallurgy, mechanical engineering and mechanics, automation and remote control, chemical physics, observatory, etc. (More than 50 major research objects).

In 1946 and 1950 the scientist was elected and then re-elected deputy of the Supreme Soviet of the USSR. And in 1947, he was one of the organizers and founders of the All-Union Society for the Dissemination of Political and Scientific Knowledge (from 1963 – Society «Knowledge»), and became its first chairman. In 1949, by the decision of the USSR Council of Ministers he was approved as the chief editor of the second edition of «Great Soviet Encyclopedia», a multi-volume, huge collective work.

In 1950, in his last book, «Microstructure of Light» Vavilov summarized the results of his works and laid the foundation for a new direction in optics, which he called micro-optics. Quantum properties of light, nature of elementary radiators, interaction of emitting and absorbing molecules at distances comparable to the wavelength of light, were examined in it from a single micro-perspective.

Conclusion. *Vavilov died on 25 January 1951 at the age of 59 years, two months prior to his sixtieth birthday. He was buried in Moscow at Novodevichy cemetery. In the same year the presidium of the USSR Academy of Sciences established the Gold Medal named after S. I. Vavilov, which is awarded to scientists for major physical discoveries and works. His name was given to the Institute of Physical Problems of Russian Academy of Sciences and the State Optical Institute in St. Petersburg. He wrote more than 150 scientific and popular books and articles. He was awarded three Orders of the country. He was in 1943, 1946, 1951 (posthumously) awarded the USSR State Prize.*

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