# *S. I. VAVILOV, THE FOUNDER OF THE SOVIET SCHOOL OF LUMINESCENCE**

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WHEN we speak of S. I. Vavilov the learned physicist (and this is by no means the only aspect of his many-sided activity, for he was endowed generously with talents; we may speak of Vavilov the historian, Vavilov the philosopher, Vavilov the popularizer, Vavilov the scientific organizer, and Vavilov the bibliophile), we must above all bear in mind his studies on luminescence, his role in the growth of this branch of optics in our country, and his role in founding the Soviet school of luminescence, which rightfully occupies a leading place in world science. We need not enumerate all of the results of Vavilov's numerous studies on luminescence which have become classics in this branch of knowledge. These studies are well known to the specialists, but it would be difficult for non-specialists to evaluate from a cursory account the significance which these studies had in their time and have retained up to the present. To gain a correct understanding and evaluation of their significance, it would be much more important to consider them in their historical perspective, and to try to draw a picture of world science during the years when these studies were being conducted.

In our century of exceedingly swift development of science, the period of twenty to forty years separating us from Vavilov's principal studies on luminescence constitutes an entire epoch. During these years, completely new approaches in science and technology have arisen and taken a firm place in our way of life. Many of these would even have been difficult to predict. If we speak only of the material manifestations of the scientific advances, we need only mention radio broadcasting and television, the utilization of atomic energy, and the orbiting of satellites and space ships. However, the advances in theory may be just as grandiose, although not as apparent. Even the conditions of scientific work have changed unrecognizably. Our laboratories are equipped with refined apparatus, and we have access to machine shops capable of building any complex design.

What were the conditions under which Vavilov began and carried out his creative life? What means did the scientists in the field of optics have at their disposal in the early twenties? What were the theoretical assumptions and technical means of research on the interaction of light with matter, in particular luminescence phenomena, in the field which the young physicist Vavilov took up at the suggestion of his teacher P. P. Lazarev, upon returning from the front? In the theoretical field, there were the beginnings of quantum mechanics, and the first attempts to create a conception of the molecular mechanism of absorption and emission of light (based on rather confused ideas of molecular resonators). Development had begun in the lines of research which had appeared in the wake of chemical physics, without which an analysis of luminescent phenomena would even now be impossible. But as for the phenomenon of luminescence itself? One cannot say that luminescent phenomena were a novelty. Indeed, they had already been studied by Galileo, Boyle, Newton, Euler, Boscovic, Petrov, and more recently by Stokes, Lommel, Becquerel, and Wiedemann. Nevertheless, even in 1944 Vavilov felt that luminescence could be considered quite young as an established discipline. Besides the inadequacy of the theoretical bases and the lack of any serious technical applications, the conversion of luminescence from a set of empirical and often curious phenomena into an independent science was greatly hindered by the lack of any decent technical equipment in the optical laboratories. For example, we cannot imagine now a luminescence laboratory without high-pressure mercury lamps. However, these appeared only just before the second world war, and Vavilov had to begin his series of studies on luminescence yield and polarization with "one-half watt" incandescent lamps, or in more favorable cases, with carbon arcs as excitation sources. The only and irreplaceable photometric apparatus was the notorious König-Martens visual spectrophotometer, which has since become a museum piece and is hardly known to most of the modern young scientists, who have been spoiled by rapid and precise photoelectric measurements. Vavilov used the König-Martens apparatus even for polarization measurements. These were, as he himself wrote, "extremely tedious measurements." Each new scientific result was gained at the cost of great effort; many of Vavilov's associates participated in the series of measurements in the studies in the Institute of Physics and Biophysics directed by P. P. Lazarev. In the research notes published in Vavilov's first papers, we readily recognize the initials of P. N. Belikov, B. V. Deryagin, S. I.'s close friend É. V. Shpol'skii, and others of Lazarev's associates. The experimental difficulties required careful design of the experiments being planned and cautious consideration of their results. Thus, Vavilov

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developed his characteristic "economical" style of work: the selection of the most basic problems of the physics of his time, the tendency to design experiments simply, and the deep analysis of the data obtained.

The vast expansion in the technical possibilities of experimentation and the discovery of the fundamental laws of the luminescence phenomenon have provided present-day researchers with limitless possibilities. The number of published papers on luminescence occupies one of the largest areas among the papers on the various branches of optics and spectroscopy. Among the specialists in the neighboring fields, there exists an opinion (not completely unfounded) that luminescence studies can be carried out without especial effort. In fact, the number of luminescent substances is endless, and the basic characteristics of the emission, which can be easily studied with modern apparatus, are sensitive to changes in the various external conditions. It is thus very easy here to lose one's sense of proportion and follow the dangerous path of least resistance, the path of recording phenomena and all of their possible relations to conditions. This pathway was foreign to Vavilov. One need only read his papers to be convinced that an original idea is expressed in every paper, even the smallest. We do not find a large number of curves in these papers. The study of the various relations of certain parameters of the emission to various factors, as is so characteristic of many current studies on luminescence, never played an independent role in S. I.'s studies. Such studies were always subordinate to some clearly formulated idea, and as a rule, were cited to answer a directly posed specific question. Vavilov could not bear attempts to complicate phenomena artificially by overloading them with clever but often groundless constructs, and with open irony classified them as "speculations." His thought was always straightforward, clear, and concrete.

In one of his first studies on luminescence, Vavilov raised the question of what the scale of the phenomena was, so to speak, and what its relation was to the Lorentz thermal absorption, which should predominate in a condensed phase, according to the notions holding sway then. The result was unexpected, as S. I. himself wrote. In spite of the classical ideas about thermal absorption, the fluorescence yield of some substances turned out to approach unity. We can hardly overestimate the significance of this result as a shock stimulating the study of the luminescence phenomenon. The latter had turned out to be by no means a side or second-order effect, but on the contrary, it was in a number of cases the major term in the energy balance of processes taking place upon absorption of light. In characterizing the efficiency of luminescent substances as transformers of light energy, this result supplied a serious basis for possible practical applications of luminescence.

This study, along with others at about the same time on the polarization of the luminescence of solutions, which had just been discovered by Weigert, determined the direction of Vavilov's major line of scientific creativity. What attracted S. I. as a scientist to luminescence? First, one can get by fairly simple means to the intimate mechanism of processes of interaction of light with matter and establish a very graphic picture of the absorption and emission of light. S. I. became interested in these problems even as a student, when in working in P. P. Lazarev's laboratory he carried out his study of the photochemistry of dyes. The luminescence of complicated molecules of organic substances seemed to be a very suitable topic for research on the elementary events in emission and absorption processes, just because of their very complexity. Whereas in studying the luminescence of isolated atoms and ions the researcher must be satisfied with the logically irreproachable but very formal and ungraphic constructs of quantum mechanics, the luminescence of complicated molecules provided a possibility to create simple classical models. Such models were incomparably closer in spirit to Vavilov's style of scientific thought, which was always exceedingly clear and concrete. S. I. became absorbed in luminescence studies, and they remained the main stem of his scientific activities throughout his life.

At the very beginning of his research in the Institute of Physics and Biophysics of the People's Commissariat of Health, S. I. drew the young physicist V. L. Levshin into luminescence studies. Differing in many ways in habits and character, S. I. and V. L. supplemented each other, fruitfully collaborated for years, and carried out several fundamental studies on polarization and on the decay laws of luminescence. This collaboration was interrupted for a short time when S. I. was appointed by D. S. Rozhdestvenskii to the position of scientific director of the State Optical Institute and moved to Leningrad, where he began to develop his luminescence studies. Their collaboration was resumed when in 1934 a number of the academic institutes were moved from Leningrad to Moscow. What happened was that, on moving to Leningrad, S. I. directed the Physics Department of the very small Physico-Mathematical Institute, at the suggestion of V. L. Komarov, who was president of the Academy of Sciences at that time. The Institute consisted then of the director, two department heads, and less than ten scientific associates. As S. I. used to say, the Institute was run by a duumvirate, himself and Academician I. M. Vinogradov. After the Academy of Sciences moved to Moscow, the Institute of Physics, which had been separated from the Institute of Mathematics and was headed by S. I., began to grow rapidly. Whoever is familiar with the present-day Lebedev Institute of Physics may imagine how great an energy had to be exerted, and how much labor had to be spent in creating this great first-class institute from a handful of scientists. The luminescence laboratory was organized among the laboratories of the Lebedev Institute of Physics, and S. I. promptly attracted V. L. Levshin into the research there. Thus, Vavilov founded two laboratories, in the State Optical Institute and in the Lebedev Institute of Physics. These have continued to be the leading luminescence laboratories in the Soviet Union.

The nucleus of the luminescence laboratory in the State Optical Institute was a group of Vavilov's associates at the University of Moscow, who had moved with him to Leningrad: B. Ya. Sveshnikov, E. M. Brumberg, and A. A. Shishlovskii. They were later joined by I. A. Khvostikov, the Belorussian doctoral candidate A. N. Sevchenko from the Physico-mathematical Institute, K. B. Panshin who met an untimely death during the blockade of Leningrad, and Z. M. Sverdlov. Still later, two or three years before the war, they were joined by T. V. Timofeeva, V. V. Zelinskii, and P. P. Feofilov. Soon after the end of the war, N. A. Tolstoĭ and A. M. Bonch-Bruevich entered the laboratory, originally as doctoral candidates of the Lebedev Institute of Physics.

The first associates in the luminescence laboratory of the Lebedev Institute of Physics besides V. L. Levshin, were V. V. Antonov-Romanovskii, M. N. Alentsev, M. A. Konstantinova-Shlezinger, and L. A. Tumerman. They were later joined by L. A. Vinokurov, A. A. Cherepnev, S. A. Fridman, M. D. Galanin, and later, during the war, by Z. L. Morgenshtern and Z. A. Trapeznikova.

Both laboratories were relatively small. Vavilov was generally opposed to the unlimited expansion of laboratories, unless they dealt with specific scientific or technical problems requiring the participation of a large staff. The number of associates in his laboratories for a long time was no greater than ten or fifteen. Moreover, himself being a person of great erudition and broad scientific interests, S. I. did not permit his associates to confine themselves to a circle of narrow "luminescent" interests. He would often switch them, with decisiveness but with remarkable tact, from one study to another showing more promise. In his laboratories, which had come to be called the luminescence laboratories, studies were being conducted on the visual observation of quantum fluctuations, an ultraviolet microscope was developed, the night-sky emission was studied, as well as the Kerr effect, etc. The small dimensions of the laboratories made it possible for S. I. himself to follow the progress of each research project attentively. The old research workers at the State Optical Institute remember how, while he was scientific director of the entire Institute, he would visit every associate in his laboratory every day with the invariable question, "Well, what's new?"

Later, when the gigantic scientific, organizational, and public duties which S. I. Vavilov fulfilled in the Academy of Sciences greatly limited his visits to Leningrad, each of his laboratory visits was condensed into a sort of production conference, in which each associate in turn had to give a detailed account of what he had done in the two weeks or a month since S. I.'s last visit. And if one had nothing in particular to boast about, then a single ironic reply from S. I. was enough to make this associate apply all his forces for the next visit, if not to make some new discovery, then at least to carry out some set of measurements. All of this trained the young associates in discipline and in responsibility for assigned duties. While he demanded persistent effort from his associates on assigned topics, S. I. encouraged in every way all sorts of scientific initiative, and would be very unsatisfied if the work amounted only to a conscientious performance of assignments. "You are working like a clerk rather than a scientist," he would say on such occasions.

I must not omit the seminars which were conducted in both of his laboratories with S. I.'s characteristic punctuality. These seminars, at which S. I. himself often presented papers, were an excellent school for the young scientists. S. I.'s seminar presentations, whether they were reviews or original communications, were always interesting, incisive, and often highly critical. S. I.'s erudition and memory always amazed us. In dealing with each seminar topic, he went over the entire history of the topic, sometimes covering decades, surprising us with his precise knowledge of dates, names, and details of studies. Vavilov's seminars in the luminescence laboratory of the State Optical Institute, the themes of which often had nothing to do with luminescence, invariably attracted a large number of the associates from the various laboratories of the Institute.

These were the circumstances under which luminescense studies in our country began and continued to grow. The number of these studies has kept increasing. Luminescence has been established as an independent discipline, and the perspectives of its technical applications have been outlined. Even in the twenties, in lectures given in the Bauman Technical College, Vavilov expressed the idea of the possibility of applying luminescent energy transformers to convert the useless ultraviolet emission of incandescent and gas-discharge lamps into visible light in order to make these light sources more economical. In the thirties, the fruitfulness of these ideas was generally recognized. This and many other practical applications of luminescence have stimulated a widespread initiation of research on the preparation and study of crystal phosphors and luminescent glasses in the Lebedev Institute of Physics, the State Optical Institute, and the affiliated institutes. The high sensitivity of luminescent analysis and the wide interest in it shown by chemists, geologists, biologists, and other specialists have furthered the growth of studies in the field of molecular luminescence. Luminescence research has begun in many places. It became necessary to coordinate these studies, and Vavilov raised the question of calling the First All-Union Conference on Luminescence. This conference was scheduled for the end of June, 1941. Its program included about twenty papers on various problems of luminescence, principally the luminescence of crystal phosphors. The sudden outbreak of war prevented the holding of the conference. During the war years, the research workers in Vavilov's laboratories tried with all their powers and capabilities to direct their research to the aid of the front. They developed and introduced luminescent (and non-luminescent) methods of camouflage. They developed infra-red-sensitive materials for signaling and night vision. They developed and introduced methods for luminescent prospecting for minerals, which had become a very pressing problem in view of the occupation of a considerable part of our territory and the necessity of searching for new deposits.

It became possible to call the First Conference on Luminescence in Moscow in October, 1944. In opening the conference, S. I. said, "Now, as we await from day to day the surrender of the maddened and weakened enemy, we can carry out a plan which has taken a long time to ripen." In spite of the difficult war conditions, more than 300 persons attended the conference, representing 113 institutions. This conference was the breakthrough point in the development of the Soviet school of luminescence.

In his introductory remarks at the conference, S. I. first formulated a rigorous definition of the luminescence phenomenon itself. He indicated the necessity of introducing a criterion of lifetime into this definition, permitting luminescence to be distinguished from other forms of secondary radiation. The great heuristic value of this supplement to Wiedemann's classic definition will be clear if we recall the story of the discovery of the Cerenkov radiation, or as it would certainly be more correct to call it, the Vavilov-Cerenkov radiation. P. A. Cerenkov, one of S. I.'s doctoral candidates in the Physico-Mathematical Institute, demonstrated in 1933 by tedious photometric and polarization experiments that the radiation universally emitted by liquids under $\gamma$-ray excitation has a vanishingly small lifetime. It immediately became clear to Vavilov that this is not a case of ordinary luminescence. In attempting to explain the phenomenon, he advanced the hypothesis that the radiation is of electronic origin. This hypothesis was developed later into a rigorous theory by I. M. Frank and I. E. Tamm. Thus one of the remarkable scientific discoveries of our time, which recently won a Nobel prize, was made.

At the First Conference on Luminescence, S. I. presented a long major paper on the photoluminescence of solutions, presenting the results of research in this field, and raising a series of problems. The basic ideas of this paper have retained their significance until now, in spite of the considerable growth in the study of luminescent molecules during the following sixteen years.

S. I. said at the conference, "On the broad front of science and technology, luminescence is only a narrow special region. This region, however, is important and necessary. This is proved by thousands of luminescence studies reported in scientific and technical journals, the numerous luminescence laboratories that are continually increasing in number, the application of luminescence at the front, and the tens of millions of fluorescent lamps produced by industry. Now, in these days of glorious victories, as the war clearly approaches its end, we must mobilize ourselves to solve the innumerable problems presented by peaceful construction."

The conference played this mobilizing role. The studies on the theory and applications of luminescence began to grow even more widely, new approaches began to appear, and new laboratories. A special commission directed by Vavilov was established in the Section on Physico-mathematical Sciences of the Academy of Sciences to coordinate the research on luminescence. The conferences on luminescence became traditional. Unfortunately, it was possible to hold only one more conference during S. I.'s lifetime.

In opening this conference in May of 1948, in a very precise and official style, Vavilov formulated the basic course of development of science in general on the basis of the particular example of luminescence research. He said, "Before the October revolution, one could count the number of physicists, chemists, and engineers in Russia specializing in the luminescence field on the fingers of one hand. Now we may agree that there are hundreds of people working in the luminescence field in the Soviet Union, even by counting the participants in this conference. During the Soviet period, our national science has been very productive in all branches of luminescence, in the study of the emission from vapors and gases, solutions, and solids. In all, insofar as we may judge, we have accomplished more than in any other country in the world.... In the Soviet Union it is more evident than anywhere else in the world that science grows both deeply and widely from the moment that a continuous link is established between theory and practice. The principal and basic lesson which we may draw from the whole history of many centuries of luminescence consists in the necessity and extreme importance of strengthening this link. Our science must continually examine life and the requirements of the state in all their variety. This is the guarantee of the correct and rapid further growth of all our science, in particular luminescence research."

S. I. presented a long paper at the conference on the migration of energy in fluorescent solutions, the problem in which he was most interested during the latter years of his life.

The third conference, which was held in the summer of 1951 at S. I.'s suggestion, was devoted to his memory. The number of participants in the conference on luminescence and the number of papers had grown with such rapidity that it was quite soon necessary to go over to holding separate conferences on molecular luminescence and on crystal phosphors.

The Soviet school of luminescence founded by Vavilov has continued its fruitful work. Besides the old centers (the luminescence laboratories in the State Optical Institute and the Lebedev Institute of Physics), large schools have originated and determined their lines of research in Minsk (under the former associates of the State Optical Institute, A. N. Sevchenko and B. I. Stepanov) and Tartu (under F. D. Klement and Ch. B. Lushchik). In Minsk, a group of theoreticians headed by B. I. Stepanov is working intensively on the development of luminescence theory. A number of studies have been carried out there on general problems of luminescence of great theoretical significance. The Tartu school of luminescence research workers originated in the studies on sublimate phosphors conducted by F. D. Klement in A. N. Terenin's laboratory at the University of Leningrad. This school has merged organically in the mainstream of research of Vavilov's school, and rightly occupies one of the leading places in its own field in the total balance of world science. In Kiev, under the direction of A. F. Prikhot'ko, studies are developing successfully on the luminescence of crystals of organic compounds. Highly interesting studies on the analysis of the line spectra of the luminescence spectra of frozen solutions of organic molecules are being conducted by an old associate of Vavilov, É. V. Shpol'skii, at the Lazarev Institute.

Numerous scientific and industrial laboratories are intensively working on problems of preparing specialized luminophors for various practical applications (fluorescent lamps; the cathode-ray screens of television sets, radar scopes, image tubes, and electron microscopes; electroluminescent screens, scintillating crystals, etc.).

We cannot even make mention of all of the scientific advances of the Soviet school of luminescence, or of the further development of the research lines in which Vavilov had his fundamental scientific interests. We shall hear about some of them in the following papers. I would like to use this report to spend just a short time on two problems in which S. I. was greatly interested over many years of his creative life. These are the problem of non-linear optics and the problem of the experimental determination of the nature of elementary emitters.

Even before he began his luminescence studies, Vavilov took up the problem of the limits of applicability of the fundamental law of light absorption, Bouguer's Law. With this goal, he conducted a series of measurements of the absorption coefficients of dyes, varying the intensity of the transmitted light over a record high of breadth of limits, a range of $10^{20}$. At that time, the most interesting range seemed to be that of exceedingly low intensities, where one might expect a great increase in absorption, according to the hypothesis of M. Planck, the founder of the quantum theory, that absorption is continuous but emission has a quantum nature. The constancy of the absorption coefficient established by Vavilov's experiments over a wide range of intensities was fatal to Planck's hypothesis, and gave evidence that absorption also has a quantum character. Later, S. I. took up again the question of the linearity of absorption, but at the other end, as it were. In 1925, his experiments with light of very high intensity (condensed sparks), performed jointly with V. L. Levshin, showed a decrease in the absorption coefficient of uranium glass by 1.5% with a mean error of ± 0.3%. This phenomenon was interpreted as being due to the relatively long lifetime of the luminescence of uranium glass, and the possibility thus arising of accumulation of an appreciable fraction of the centers in the excited state.

The clearly marked non-linear phenomena in crystal phosphors, where the lifetimes of the excited states may be especially long, permitted K. B. Panshin to realize shortly before the war Vavilov's idea of building a certain type of absolute photometer not requiring a standard comparison source.

The violation in such cases of linearity, which is one of the fundamental principles of ordinary optics, permitted Vavilov to raise the question and suggest the course of development of a new line of research, "nonlinear" optics, which examines critically the constancy of characteristics of matter such as absorption, dispersion, birefringence, dichroism, etc. As Vavilov wrote in 1944, individual "problems of this sort may be solved by very crude and primitive simplifications, rather than by the rigorous analytical method. Sometimes, and even often, this is sufficient, but still, for a long time we have had to know how to solve such problems lege artis. We must not forget that the real optics of matter with which we deal is non-linear in the general case, and its treatment requires a 'non-linear' mathematical apparatus."

At present, the creation of such an apparatus has begun. First of all, I would like to mention here the studies conducted in the State Optical Institute by A. P. Ivanov, and those conducted in Minsk under B. I. Stepanov's direction. Ivanov's study provided an important and at first glance amazing result: in systems describable by a diagram with two energy levels, as is usual in molecular luminescence, the possibility of observing nonlinear effects does not depend on the lifetime of the excited state. The physical meaning of this apparently paradoxical result is obvious: the possibility that the system may stay longer in the excited state is exactly compensated by the greater difficulty of transition to this state, in view of the known relation between the Einstein coefficients.

On the basis of this result, we might suppose that the violation of linearity of absorption observed in the experiments of Vavilov and Levshin with rather modest experimental means is evidence that the uranium glass which they studied must be considered to be a system with three levels, rather than two. This system would thus exhibit complete analogy with the typically nonlinear systems in which a situation of negative absorption can be realized, and which at present are beginning to be applied as light amplifiers and generators.

We encounter similar nonlinear effects, but occurring at relatively low light intensities, in another novelty of contemporary optics, the so-called "optical pumps," in which the action of circularly-polarized light on the medium leads to a redistribution of the atoms among the components of the ground state, i.e., to the orientation of the atoms, and hence, to a decrease in the absorption coefficient.

Thus, we are witnesses in our time of the fact that the problem of nonlinear optics, precisely in the sense in which Vavilov understood it, has become the front line of science.

The second problem, about which I would like to say a few words, involves the determination of the nature of elementary emitters. Those who have had occasion to discuss problems of optics with Vavilov certainly remember the animation with which he discussed this problem, understanding the nature of emitters to mean their multipole character. Vavilov developed a number of original methods for the experimental determination of the nature of elementary emitters. However, unfortunately, it was possible only after his death to discover by these methods a series of emitters more complex than the simple classical linear dipole. In developing general methods of determining multipole character, Vavilov continually took up one particular problem, that of determining the nature of the emission from the uranyl ion.

In spite of the vast number of studies concerning the spectroscopy and luminescence of uranyl salts, the fundamental problem of the multipole character of the elementary transitions responsible for the absorption and emission of light was not solved until recently. S. I. repeatedly returned to this problem, persistently seeking out various ways to solve it. The problem consisted in the necessity of reconciling the long lifetime of the luminescence (in an undoubtedly monomolecular process) with the dipole character of the emission, as established from the polarization diagrams of the luminescence of uranium glasses. The interference and polarization experiments carried out during Vavilov's lifetime under his direction gave no definite answer to this problem. In a paper at a scientific meeting at the Leningrad State University in November, 1945, S. I. said, "Thus, we may naturally consider that the elementary emitter in the luminescence of uranyl salts is a magnetic dipole," while a little over a year later, at the first D. S. Rozhdestvenskii Lecture in March, 1947, he came to the opposite conclusion, "In any case, there exist at present more arguments in favor of the idea that we are dealing with an electric dipole than with any other system." Today I cannot refuse the pleasure of reporting that the problem raised by S. I. Vavilov has been solved unambiguously during the past year by a study of lithium and sodium fluoride crystals activated by hexavalent uranium. The application to these systems of the polarization-diagram method proposed by S. I. Vavilov was extended by us, on the one hand, to the case of magnetic emitters, and on the other hand, to cubic crystals. Thus, we showed that we are dealing here with a superposition of different multipoles. Part of the lines in the spectra correspond to magnetic dipoles, and part to electric dipoles. Thus, it would seem, both mutually exclusive statements of Vavilov turned out to be right. Does not this answer clear up the problem of the nature of the luminescence of uranyl salts? Not at all! As often occurs in science, the solution of one problem has given rise to the appearance of a series of new problems. For example, when the forbidden character of the electric dipole transitions is partially relaxed (we can show that they are forbidden from the long lifetime of the emission), why is their intensity just the same as that of the corresponding spontaneous magnetic transitions? At liquid-helium temperatures, at which the electronic-vibrational series in the luminescence spectra produced by electric dipoles are "frozen out," why are the corresponding resonance lines retained in the absorption spectra (corresponding to the purely-electronic transitions), although it would seem that the ratio of the probabilities of direct and reverse transitions must not depend on the temperature, etc.? The solution of certain of these problems must lead, as it seems to us, to conclusions with significance extending beyond the framework of the particular problem from which they originated.

These two particular problems show what possibilities are latent in Vavilov's scientific inheritance. Our duty, and the duty of all the research workers in the Soviet school of luminescence founded by Vavilov, is to study this inheritance, to read attentively Vavilov's scientific and popular works, his brilliant papers and speeches, which take a rightful place in the golden fund of our national culture. Many of the pages which he wrote will undoubtedly compel us to take a fresh glance at our daily work and its results, and comprehend them from some more general viewpoint, and make us meditate on many of the yet unsolved problems of optics.

Translated by M. V. King