

## SKETCHES FOR A PORTRAIT OF S. I. VAVILOV

From the editors. This is the third collection of recollections about S. I. Vavilov to be printed in this journal (for the first two collections, see *Usp. Fiz. Nauk* 111, 173 (1973) and 114, 533 (1974), [*Sov. Phys.-Usp.* 16, 702 (1974) and 17, 950 (1974)]).

All these contributions will form part of a collection devoted to the memory of S. I. Vavilov. The collection will be edited by I. M. Frank and will be published by Nauka Press.

The Editorial Board consider it their pleasant duty to thank all the contributors to this series and, in particular, I. M. Frank, who suggested and organized the entire project.

### Recollections of S. I. Vavilov

É V. Shpol'skiĭ

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#### Photometry of Sources of Different Color

I first met Sergeĭ Ivanovich Vavilov in the Fall of 1911, soon after the closure of Moscow University by Minister Kasso. I was then attending the second course and Vavilov the third. These "courses" were somewhat arbitrary because the University was still operating the "subject system" in which each student had to attend lectures and pass examinations in the subjects in his curriculum, but could do so in any order.

Having returned to Moscow from the forced vacation in the Fall of 1911, I decided to become a formal university student and to concentrate my work in the Shanyavskii University to which P. N. Lebedev and P. P. Lazarev were forced to repair. S. N. Rzhavkin [*Usp. Fiz. Nauk* 114, 538 (1974); *Sov. Phys.-Usp.* 17, 953 (1974)] has given a lively description of the arrangements in this minute laboratory on Volkhonka in the Golitsyn house (at No. 14), where the weekly colloquia or, as we now call them, seminars used to take place.

I met Sergeĭ Ivanovich during one of these colloquia (probably the first). The colloquia took place in a large hall in the house which was converted into an auditorium. The participants in the colloquium were regarded as equals even though they included senior members of the "Lebedev Laboratory" and students, including, of course, Sergeĭ Ivanovich. Among the more senior participants, other than P. P. Lazarev who led the colloquium, T. P. Kravets attracted attention by his extensive erudition and lively style. Lebedev himself participated in one of the first colloquia.

Sergeĭ Ivanovich worked not in the minute laboratory on Volkhonka, described by S. N. Rzhavkin, but in the laboratory specially set up for P. N. Lebedev and his more senior pupils on the ground floor of the house at No. 20, in the then Mertvyĭ Pereulok (now Ostrovskii Pereulok). On the ground floor of this house there were two apartments arranged one opposite the other. As far as possible, these were adapted to function as laboratories. The apartments on the upper floors were taken by P. N. Lebedev and P. P. Lazarev. The left-hand apartment on the ground floor contained P. N. Lebedev's study, two laboratory rooms for his senior staff (A. K. Timiryazev, V. I. Romanov, and others) and a workshop. The first room in the right-hand apartment was the personal library of P. N. Lebedev, who placed it at the disposal of everyone. The library was valuable because

it contained long runs of leading German physics journals, and an extensive and systematically arranged collection of reprints sent to Lebedev by other workers. The door from the library led to a large room in which Sergeĭ Ivanovich was working. He shared it with N. T. Fedorov, subsequently a well-known specialist on the theory of color, and D. D. Galanin.

I frequently visited this laboratory and worked in the library. By common custom, continuing from the time of the University laboratory, there was no librarian, and all the cupboards were open and accessible to both senior and junior staff, who freely used the books, journals, and reprints. Since the number of people working in both laboratories, i.e., on Volkhonka and in Mertvyĭ Pereulok, was small, the library was frequently the forum for spontaneous discussions of new work.

Even then, Sergeĭ Ivanovich was distinguished by great erudition and always participated in these discussions. Once, as a result of a discussion of the work of I. S. Plotnikov, the photochemist, P. P. Lazarev assigned to me my first project. At that time, P. P. Lazarev implemented P. N. Lebedev's rule that every new scientist had to start an independent project during the second course at the University. I mention this event in my life because, as will be clear from the ensuing account, it led to a closer relationship with Sergeĭ Ivanovich. The project given to me by P. P. Lazarev was concerned with one of the photochemical reactions, which was natural enough because, shortly before that time, Lazarev had defended his doctoral dissertation on the bleaching of dyes (visual purple) in the visible spectrum, i.e., on photochemistry. P. P. Lazarev used an ingenious method by which the process under investigation could be examined optically (through bleaching). This reduced the study of the kinetics and energetics of the process to spectrophotometric measurements with a very convenient instrument, namely, the Koenig-Martens spectrophotometer.

Since, in my project, the process which I was studying was also detected through a change in the absorption of light (iodine was released in the solution), P. P. Lazarev suggested that the method described in his dissertation should be used in my experiment.

I immediately began to consider in the library how the Lazarev method could be applied to my problem. However, to my great chagrin, I did not succeed in find-

ing a solution to this problem, despite a number of abortive attempts.

First of all, one could hardly expect to have free access to a Koenig-Martens spectrophotometer in our minute laboratory, so that a home-made instrument had to be built. But the main difficulty was fundamental: in contrast to the bleaching studied by P. P. Lazarev himself, the process which I had to investigate involved an increase rather than a reduction in the absorption, and this led to considerable difficulties.

Whilst I was racking my brains looking for a solution, Sergeĭ Ivanovich walked through the library back and forth, several times, on his way to different parts of the laboratory. He finally approached me, saying "you seem to be very attached to your problem." I told him about my difficulties and he immediately became interested and began to discuss the question with me. He readily appreciated the point and agreed that my difficulties were real, but thought that they could be overcome by the method of sources of different color, commonly used in photometry. He pointed out that "one way of overcoming this difficulty is to use a photometer in which, instead of balancing the intensities, one uses flickering illumination and adjusts the system until the flicker disappears. This is the principle of the so-called flicker photometer used in the photometry of sources of different color. I will look through the literature and let you have some more detailed suggestions." He did this and, eventually, the review section of "Zhurnal Russkogo Fiziko-khimicheskogo obshchestva" published a paper by S. I. Vavilov entitled "Photometry of Sources of Different Color." As far as I know, this was the first paper published by Sergeĭ Ivanovich.

### Rebirth of "Uspekhi Fizicheskikh Nauk"

As far as anyone could remember, the Vavilovs lived in their own tiny wooden house on Srednaya Presna (now Zamorenov Street). Sergeĭ Ivanovich's room was on the second floor and was full of shelves bearing books and scientific periodicals. About 1920, the Vavilovs and, in particular, Sergeĭ Ivanovich's mother, Sergeĭ Ivanovich himself, the first wife of his elder brother (the eminent botanist Nikolaĭ Ivanovich), and the son of Nikolaĭ Ivanovich moved to a large apartment in a house near the Belorusskiĭ Station. Nikolaĭ Ivanovich himself was traveling most of the time, and when he settled down in a given place it was usually Petrograd, where he established the Plant-Growing Institute. However, Sergeĭ Ivanovich found the new apartment very inconvenient. At that time, I was living in a quiet alley between Arbat and Kropotkinskaya. This alley consisted of only four houses and one of them, with six floors, was larger than the others and was ironically referred to as Bol'shoĭ Uspenskiĭ (today, Bol'shoĭ Mogil'tsevskiĭ). I was still unmarried and had a room in that house. The apartment next door was occupied by Viktor Aleksandrovich Vesnin, the distinguished Soviet architect. It so happened that, during this period, Sergeĭ Ivanovich was looking for a quiet room, and Natal'ya Mikhaĭlovna (née Bagrinovskaya), the wife of Viktor Aleksandrovich, asked me if I could recommend a colleague who could live in with them as a lodger, because their apartment was too large just for two people. I immediately mentioned Sergeĭ Ivanovich and warmly recommended him to the Vesnins. And so it happened that Sergeĭ Ivanovich and I found ourselves not only in the same house but even in neighboring apartments: I at No. 13 and Sergeĭ Ivanovich at No. 14.

This was not only very convenient and agreeable (at any rate for me and, I think, for Sergeĭ Ivanovich, too), but also, at that time, there were many events in physics one wanted to discuss. In fact, there was plenty to discuss: the theory of relativity, the Bohr atom, the Bohr-Sommerfeld quantization, and so on and so on. We met practically every evening and constantly discussed these problems.

One event which I want to describe here occurred at about that time, namely, the "second coming" of the journal "Uspekhi Fizicheskikh Nauk." This journal was originally established by P. P. Lazarev and was one of his many scientific publishing projects. The first issue of the review journal initiated by Petr Petrovich was published in 1918. It was planned to appear under his editorship as a quarterly (80 pages in each issue), and was intended to "familiarize physicists, chemists, biologists, technologists, and teachers with modern research in physics and adjacent fields of knowledge." The scientific secretary of the journal was B. V. Il'in (subsequently professor at Moscow State University), and the journal did in fact come out. Judging by the title page, the printing of the first issue was completed on April 29, 1918. However, the First World War cut off Russia from the rest of the world insofar as scientific literature was concerned. The editorial board could not, therefore, implement this very modest program and in 1918 only three instead of four issues was published, the third being somewhat larger than normal and was regarded as a double issue, Nos. 3-4. The journal then ceased to appear because of lack of material, and B. V. Il'in did not seem to be particularly interested in continuing publication. It lapsed for two years, but sufficient information had accumulated by 1920 for the journal to reappear, and there was no one willing to undertake the task of publishing it. An apparently minor event then occurred and, in the end, turned out to be decisive. Sergeĭ Ivanovich was in receipt of a large number of foreign scientific journals which frequently arrived after considerable delay. They included a much-expanded issue of the well-known German weekly, "Naturwissenschaften," devoted to Max Planck on the occasion of his sixtieth birthday and published as far back as 1918. This issue contained an outstanding paper by P. Z. Epstein, a pupil of Sommerfeld, which attracted considerable attention. This paper was serious but readable, and gave a systematic account of "Application of the Theory of quanta to the theory of spectral series," in which we were particularly interested at the time. This paper eventually reached my hands and made such a favorable impression that I not only read it but translated it in its entirety. It then occurred to me that this was the sort of article that might be suitable for Uspekhi, and I mentioned this to Sergeĭ Ivanovich. He was very much in favor of my suggestion and promised to write several papers for the proposed issue of Uspekhi. A few days later we received (I am not sure now how) the paper by Victor Henri, the physical chemist who was also the discoverer of pre-dissociation. The paper was entitled "Modern scientific view of the world" and was an introduction in the best sense of the word. Having collected all this material, I went to see Lazarev, placed the voluminous manuscript in front of him and said "Petr Petrovich, let us continue the publication of Uspekhi." Petr Petrovich was very surprised and, after a brief pause, said "Very well, I will give you a paper on the Kursk magnetic anomaly." The manuscript of this paper was delivered a few days later, and it was added to the rest of the material which

made up the first issue of the second volume. This was the beginning of the new life of Uspekhi, which has continued to this day. Petr Petrovich was not at all jealous. He had plenty to occupy him so that, when someone volunteered to take on the heavy work of publishing a journal, he was quite glad to pass on the responsibility. In fact, he gave me carte blanche in the management of the journal, which I fully exploited although my name was not mentioned anywhere in the periodical. Sergeĭ Ivanovich was particularly interested in this journal throughout the rest of his life. He wrote and translated papers, wrote review articles, and reviewed books. Since he carefully followed the scientific literature, he constantly drew my attention as editor to new fields in physics, which he considered worthy of illumination. As President of the USSR Academy of Sciences, he was occupied to the limit by his official duties, but he always found time to assist Uspekhi.

A major event occurred in his personal life while Sergeĭ Ivanovich was living with the Vesnins: he met Ol'ga Mikhaĭlovna Bagrinovskaya, the sister of Natalia Mikhaĭlovna Vesnina, and this eventually resulted in their marriage. It would be difficult to imagine a better matched couple. Ol'ga Mikhaĭlovna was a highly cultured, widely read, and very wise person. She was a wonderful companion for Sergeĭ Ivanovich.

### Vavilov-Cerenkov Radiation

In 1932, the Moscow friends and collaborators of Sergeĭ Ivanovich were both gratified and disappointed. They were gratified because Sergeĭ Ivanovich was appointed Scientific Chief of the State Optical Institute on the initiative of Academician D. S. Rozhdestvenskiĭ. This was the largest optical institute in the world, and the appointment was a recognition of the scientific work of Sergeĭ Ivanovich. On the other hand, his Moscow friends and collaborators were sorry to see Sergeĭ Ivanovich transferred to Leningrad. However, he kept in touch with Moscow and Moscow University and, in fact, spent a few days in Moscow every month. He always stayed with me, and on two occasions in 1933 he invited me to Leningrad for a few days as his guest. This invitation was connected with an important event, namely, the fifteenth anniversary of the Optics Institute. As soon as I arrived, he reported to me two remarkable observations made by P. A. Cerenkov, who was then his research student. "You know," said Sergeĭ Ivanovich, "I have long wanted to investigate luminescence induced by gamma rays. I have now assigned this topic to Cerenkov, one of my research students, and he has in fact observed a very weak blue radiation when he first examined the emission of radiation by solutions of uranium salts. However, this is not the blue emission which one can readily observe under illumination by ultraviolet radiation in solutions, and which is due to the presence in water of "dead bacteria" (a picturesque phrase of Sergeĭ Ivanovich). The blue radiation is true luminescence in all its aspects. The weak emission observed by Cerenkov, on the other hand, is not luminescence, and this is the main point." Sergeĭ Ivanovich subsequently put forward a series of serious arguments showing that the emission observed by Cerenkov was not luminescence. In fact, Cerenkov observed this emission not only in solution but also in very pure solvents. It turned out that the liquids investigated by Cerenkov (water, paraffin, benzene, toluene, and so on) exhibited this emission in a form acutely different from luminescence. Experi-

mental work on this was exceedingly difficult, because the emission intensity was very low, but Cerenkov succeeded in his task with great excellence. His work was published in Doklady Akademii Nauk in 1934, and Sergeĭ Ivanovich reported all his theoretical ideas in a separate publication. He did so (as he himself pointed out) in order not to interfere in Cerenkov's submission of his work as a Candidate's Dissertation. The complete theory of Cerenkov radiation was developed by I. M. Frank and I. E. Tamm in 1937, and the three of them, P. A. Cerenkov, I. M. Frank, and I. E. Tamm, were awarded the Nobel Prize in 1959. By that time, Vavilov had died.

I was honored to be nominated as Cerenkov's opponent in his defence of both his Candidate's and Doctoral Dissertations.

### Bol'shoe Tsarevo

Vavilov usually spent his holidays in the country with his family. In those days, Sergeĭ Ivanovich never went to summer resorts. I recall the summer of 1930 with particular pleasure. Our two families spent their holidays in the tiny village called Bol'shoe Tsarevo. The entire village consisted of only eight houses, and was located in a very picturesque area. It lay on one side of a major road not far from the Usovo Station, which was the terminus of a railroad line passing through Barvikh, now a well-known town. We, i.e., my family, succeeded in renting a new and still unoccupied house in Bol'shoe Tsarevo, whereas the Vavilovs were living just across from us and we frequently met.

Sergeĭ Ivanovich enjoyed an unusual form of vacationing: the first three days of a week he spent in Moscow where, free from teaching duties, he strenuously worked both in the laboratory and at home. He ate irregularly, his meals consisted mainly of tea and cakes, of which he was particularly fond. At the end of the week, he returned to the country and rested although he practically always did some writing even there.

During the first three days of the week in Moscow, Sergeĭ Ivanovich spent his evenings "eliminating ignorance" (these were his own words) in the field of geometric optics. Of course, by "ignorance" Sergeĭ Ivanovich meant inadequate knowledge of advanced theories of geometric optics and "to eliminate ignorance" he read the relevant articles in a fat volume of the physics "Handbuch" of Geiger and Scheel.

As far as I was concerned, I, too, spent my time in the country usefully, reading "The Structure of Line Spectra" by Pauling and Goudsmit.<sup>1)</sup> This book should not be confused with the book by Pauling and Wilson entitled "Quantum Mechanics."

The book by Pauling and Goudsmit was based entirely on the vector model. This was done deliberately by the authors who assumed that the vector model would continue to be used for many years in the interpretation of spectra. Despite its shortcomings, this book was extremely useful to me and I am very indebted to its authors. In the course of my meetings with Sergeĭ Ivanovich, I shared my impressions of this work. He discussed this work purely classically, and I purely quantum-mechanically.

<sup>1)</sup>L. Pauling and S. Goudsmit, *The Structure of Line Spectra*, McGraw-Hill, New York (1930).

As a relaxation, we used to go to the nearby birch grove, "hunting" for white mushrooms. Sergeĭ Ivanovich was a great expert in this complicated art, whereas I was quite useless.

A congress of Soviet physicists took place during that summer in Odessa. I do not cite its number because there is considerable confusion about this. In a word, I am referring to the All-Union Congress of Physicists in Odessa in which foreign scientists participated. Sergeĭ Ivanovich and I decided to travel to the Congress direct from the country, and went straight to the railroad station without going to the town. The Congress attracted a large number of delegates, including many eminent foreign physicists. I will not mention many of the well-known names because it is easy to make a mistake after such a long time. I mention only those whom I clearly remember. They included Bothe, who had just discovered (together with Becker) the "strongly penetrating

$\Lambda$ -radiation" which was soon to be shown by Chadwick to have been a stream of neutrons. There was also Sommerfeld, whose paper on the theory of metals attracted an overflow audience. Of course, one remembers the monumental figure of Pauli. He was constantly engaged in solving physics problems, even on the way between the University where the Congress took place and the hotel where he was staying. This was clear from the concentration with which Pauli walked along the street, gesticulating slightly. Sergeĭ Ivanovich read a paper to one of the parallel sessions of the Congress. I have only a vague memory of this paper.

At the end of the Congress, the delegates were taken for a trip by motorlaunch from Odessa to Batumi and back. However, Sergeĭ Ivanovich and I decided not to take part (for reasons which I do not now recall) and returned to Bol'shoe Tsarevo the same way we went to Odessa.

## S. I. Vavilov—teacher of young scientists

V. A. Fabrikant

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I first met Sergeĭ Ivanovich Vavilov in 1925 when I was a student, attending the first course in the Physics Department of Moscow University. My generation was very lucky. Between 1925 and 1930, while I was a student, our teachers included S. I. Vavilov, G. S. Landsberg, L. I. Mandel'shtam, and I. E. Tamm. Postgraduates A. A. Andronov, A. A. Vitt, M. A. Leontovich, and S. E. Khaikin also participated in various types of activity with the students.

We felt our teachers' preoccupation with science, and this had a very strong effect on the formation of our outlook generally. Sergeĭ Ivanovich immediately captured the hearts of the students, whom he treated as equals. He did this without trace of compulsion, quite naturally. We were immediately struck by the breadth of his interests and knowledge. He presented a surprising combination of restraint and sociability. And he readily shared his thoughts and worries.

We gradually began to understand the originality of Sergeĭ Ivanovich as a scientist and valued his characteristically unhurried but penetrating approach to the problems of science and its history. His cast of mind could be described by the somewhat old-fashioned phrase "natural philosopher" although he was always closely in touch with the latest events in physics.

Sergeĭ Ivanovich had a sense of humor which we found attractive. I recall one particular general physics laboratory class. Sergeĭ Ivanovich appeared unexpectedly and made us watch a female student trying to adjust the vertical position of a cathetometer (which was nearly falling over) through the fine adjustment of the micrometer screw instead of first arranging the instrument to be vertical "by eye" and then methodically using the screw for precise vertical adjustment. Sergeĭ Ivanovich bit his lip trying not to laugh aloud, but one could see the twinkle in his eye! He then tried to explain to the student without offending her how she should proceed. For us, this was a lesson in a reasoned approach to instrumentation which we were unlikely to forget.

Sergeĭ Ivanovich's enthusiasm for the history of physics was unavoidably reflected in our own interests. I recall the animated discussion between S. I. Vavilov and L. I. Mandel'shtam in 1927, just after the publication of the third volume of "History of Scientific Literature in New Languages" by Leonardo Olschki which was devoted to Galileo and his period. Some years later, this book was translated into Russian and some of the thoughts in the brilliant paper "Galileo in the History of Optics" by Sergeĭ Ivanovich were clearly stimulated by Olschki's book, especially the emphasis on Galileo as a popularizer of science, writing in the native language rather than in scientific Latin.

I have since been reminded, in somewhat unusual circumstances, of all that I had learnt about Galileo directly from Sergeĭ Ivanovich and from his books.

This happened in 1964 in Florence. I was attending a reception at Palazzo dei Signori, given by the Mayor of Florence for the delegation from "Znanie", a society of which I was a member. The Mayor, a professor of Roman law, made an emotional speech and, unexpectedly, I discovered that I had to reply. I was rescued from my embarrassment by Sergeĭ Ivanovich. It frequently happens that, in a moment of danger, one's memory becomes sharper. On that occasion, without a mere twinge of conscience, I simply repeated all that I learnt from Sergeĭ Ivanovich about Galileo. This was very appropriate because 1964 was the 400th anniversary of the birth of Galileo. The Mayor was clearly surprised and touched by this piece of plagiarism.

In the fall of 1930, Sergeĭ Ivanovich telephoned and asked me to give the course on physical optics at the Moscow Engineering Institute which he previously gave himself. Naturally, I tried to decline but Sergeĭ Ivanovich insisted that I did it. I then asked for the syllabus of the course. His reply was that he changed it from year to year and asked me to call on him at his house so that we could discuss the content of the course. I do not remember precisely what was said at this discussion, but I do