The Shpol'skiĭ effects (On the hundredth anniversary of the birthday of É. V. Shpol'skiĭ)

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> "The natural scientist faces a strict and impartial judge—nature. In his experiments and measurements, amidst a wide range of phenomena he passes through the great school of truth in judgement and action. To draw the thoughts and emotions of youth into contact with this realm exceptional in its inexhaustible vitality, purity, and creativity, is the lofty mission of teachers of physical sciences."
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> *N. A. Umov*

September 24 of this year marked the hundredth anniversary of the birth of Éduard Vladimirovich Shpol'skiĭ (1892–1975).

For earlier generations of physicists, the name of Shpol'skiĭ is primarily associated with this journal, which he created with S. I. Vavilov and P. P. Lazarev in 1918, and which he directed from the second volume to his death.

For many generations of students, the name Shpol'skiĭ is associated with the two-volume textbook *Atomic Physics* (in Russian) which was first published in 1944. The seventh and last edition came out in 1984.

Specialists in the field of molecular spectroscopy cannot be ignorant of the research of Shpol'skiĭ and his students on the study of the spectra of the luminescence and absorption of a wide range of organic compounds (polycylic aromatic hydrocarbons) and his 1952 discovery of the phenomenon of spectral band contraction in *n*-paraffin solutions of these compounds at low temperatures (the Shpol'skiĭ effect). Shpol'skiĭ was awarded the State Prize for this work in 1970, and the discovery was recorded in the State Register of Discoveries of the USSR after his death (the authors are É. V. Shpol'skiĭ, A. A. Il'ina, and L. A. Klimova).

Unfortunately, there are few who remember that for more than twenty years the name of Shpol'skiĭ could be found on the title page of the review journal *Fizika* (in Russian). Shpol'skiĭ was the editor-in-chief of this journal from its inception.

Shpol'skiĭ was not an academician, nor was he a corresponding member of the Academy of Sciences. From 1932 he taught at the V. I. Lenin Moscow State Pedagogical Institute. At first he taught in the physics department, and from 1939 to 1972 he headed the department of theoretical physics.

Now one can attempt to find the root of Shpol'skiĭ's remarkable creative consistency and longevity. He spent 56 years with this journal, 43 years at the Moscow State Pedagogical Institute, 22 years at the journal *Fizika*, and *Atomic Physics* has been in the hands of students for about a half-century. He created a scientific school with a burst of scientific activity at an age when others retire.

The author of these lines was fortunate to have been a student of Shpol'skiĭ's and to have spent more than twenty years working with him in the department of theoretical physics at the V. I. Lenin Moscow State Pedagogical Institute.

1953. A small laboratory with no staff and no scientific research status. Simply an optical laboratory in the department of theoretical physics. Part of a wide corridor separated off by a dividing wall. Beyond the door to the left, a lathe, to the right, a Bausch and Lomb quartz spectrograph on a long table, and on another table a comparator. Here fourth-year students conducted a practicum in spectroscopy. Straight ahead is another dividing wall, and beyond the door a tiny room, proudly called an office, to which we, two graduate students, had access in the evenings when there were no instructors and no students. In photographic recording of spectra exposures lasted 12–15 hours. The laboratory itself was in a room 30–35 square meters in area to the left of the corridor. How mysterious this room was! It was almost always dark, with something burning, nitrogen vapor rising from open glass Dewar vessels. A hugh beautiful Zeiss recording microphotometer occupied not quite a quarter of the room. On other tables were small spectrographs, a glass Fuss and a quartz Hilger model, hand-made photometric set-ups, the housing of mercury lamps made from sections of rain gutters. On the walls something was stretched, suspended. In the very passageway was a large lever rheostat with shiny open contacts. Overall everything was remarkably beautiful. That is how I recall the laboratory, where it seemed at night the throttles humming under the tables grew quite, the solution frozen in liquid nitrogen burned brighter and we, in the darkness, wiped dust or rust from our fore-

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heads or cheeks with the sleeves of our overalls as Shpol'skiĭ appeared in the door. The boss cast an eye over the laboratory, nodded his head and disappeared into the office. At the time, Shpol'skiĭ himself did not work in the laboratory, but he loved experiments, and he was personnally involved in the acquisition of new instruments for the department (the laboratory did not exist "on paper" at that time), and regularly drove to all the collection points from which the equipment for pedagogical institutes and schools was obtained. One day Shpol'skiĭ delivered from Leningrad, from the State Optico-Mechanical Factory (now the Leningrad Optico-Mechanical Association), a bill for a wide-aperture lens. We were amazed when freight weighting about 50 kg arrived at the department. This was actually the lens for some sort of artillery system with a base the size of a desk. Shpol'skiĭ managed to trade it for something else.

Sometimes it seemed that for Shpol'skiĭ the experimental method was primary, and the scientific problem was secondary. There is a list of subjects for research which he tossed off in his own hand in the late 40s (apparently a draft of some plan) with a complex system of headings. The first is "Development of methods of photoelectric spectrophotometry," Then for several pages there are the themes of specific papers in scrawled handwriting with an indication of the literature (sometimes the reference looks like this: L. Tumerman, report at the Lebedev Institute colloquium). Then, point by point the study of absorption, fluorescence, reflection and scattering spectra is planned. The objects of investigation are different, but the attraction to biology can be clearly traced.

For more than twenty years Shpol'skiĭ was interested and involved in the application of optical, inlcuding spectral, methods to biological problems. He loved this work, and I recall he often talked about it. Shpol'skiĭ always valued serious, good practical research. It was this type of work which led him to the discovery of the effect named after him.

In the front of me is a copy of a 1948 article published in *Izvestiya, Academy of Sciences, USSR, Physics Series* by É. V. Shpol'skiĭ, A. A. Il'ina, and V. V. Bazilevich entitled "Flourescence Spectra of Some Polycyclic Aromatic Hydrocarbons." "This article arose in conjunction with the study of the spectra of fluorescent analysis of carciogenic hydrocarbons, but was later expanded." And it was really expanded. From the concluding paragraph of the paper it is clear that the authors went far beyond the limits of the problems of spectral-luminescent analysis: "The solution to the riddle of why certain substituents transfer especially high biological activity to the molecule should obviously be sought in other physical or physico-chemical properties of these molecules. From this point of view, a broad study of optical and other physical properties of carcinogenic and noncarcinogenic hydrocarbons is of particular interest." (As far as we know, this riddle has not yet been solved.)

Today researchers have various modern spectrofluorometers, and are equipped with computers and recording systems. In that ancient work, the fluorescence spectra of 22(!) componds were obtained using a method which is unthinkable from the point of view of the modern experimental physicist: "To measure the fluorescence spectra we used photoelectric equipment with a quartz monochromator and a antimony-cesium photoelement... ." In another, shorter article published the same year in *Doklady of the Academy of Sciences of the USSR* the experimental method was described in further detail: "The drop in potential across a high resistance (a set of three resistances, $4\cdot10^8$, $8\cdot10^8$, and $1\cdot10^{10}$ Ω) was measured using a Lindeman electrometer, which was very well suited to this purpose. A microprojector was used for observations, and this made it possible to reckon the position of the needle of the electrometer on a scale of 100 divisions with the same ease as in any needle instrument... . In order to eliminate the possible inconsistency of the source, after 1–2 readings the measurement of the intensity of fluorescence was repeated at some standard wavelength (usually 410 nm) and the entire series of readings I_λ was reduced to a single value I_{410}." There is no need to explain that it took about one hundred readings to obtain one spectrum. Later, photographic recording of spectra, even in exposures of many hours, with subsequent processing of the spectrograms using the "beautiful" microphotometer seemed to be the ultimate in progress.

Let us return, however, to the "idealogical" side of the work. In publications in 1948–1950 medical and biological problems still formed the cornerstone. But Shpol'skiĭ, the highly trained physicist, immediately perceived, even felt, that he was dealing with objects which were interesting and important not only from the point of biology or medicine, but also from the point of view of general problems in the physics of complex molecules.

By that time theoretical examination of general rules governing the electron-vibration (vibronic) spectra of polyatomic molecules could be found even in textbooks of quantum mechanics. However, the theory could only be illustrated with the absorption or emission spectra of molecules that were rather simple in structure (for example, benzene vapor). At the same time, due to the well-known research of S. I. Vavilov, A. N. Terenin, V. L. Levshin, and their students devoted to the study of the luminescence of solutions of organic dyes, a broad range of experimental material was collected on diffuse, unstructured spectra with little in common with those predicted by pure theory. It was customary to explain this qualitatively by a large number of closely spaced vibration sublevels which were broadened due to the effect of the medium, forming a kind of a quasi-continuum. A developed vibrational structure was observed and studied in detail in the spectra of molecular crystals (at 20 K) of simple aromatic hydrocarbons, such as benzene and naphthalene, beginning already in the 1930s (I. V. Obreimov, A. F. Prikhot'ko, K. G. Shabaldas, and later V. L. Broude and M. T. Shpak with coworkers).

Thus, the efforts of physicists were directed toward the study of completely different physical systems. In the one case, room temperature liquid solutions of organic dyes with the low level of symmetry characteristic for these complex molecules and a tendency toward different associations, and in the other case, low temperatures, high-symmetry molecules densely packed into the lattice of a molecular crystal. Shpol'skiĭ and his colleagues hit the "intersection" of these systems as soon as they undertook the study of the spectra of solutions at a low temperature (1950–1951). The objects of investigation were polycyclic aromatic hydrocarbons (PAHs). Structurally, the molecules of PAHs are more simple, homogeneous, and symmetrical than dye molecules, and more complex than molecules of benzene or naphthalene (molecules of PAHs are a condensed system of benzene

É. V. Shpol'skiĭ. Lecture in MSTI (1958).

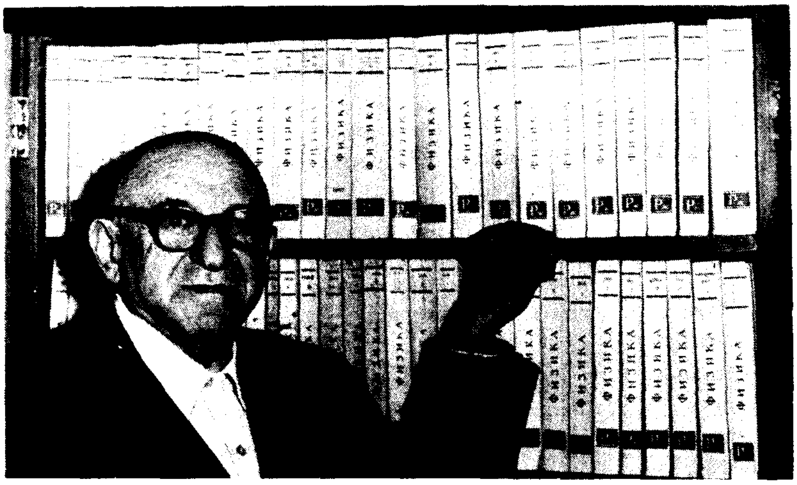
rings). Shpol'skiĭ investigated the spectra of solutions, but at low temperature. Usually at low temperatures the spectra of transparent nonscattering media are studied. In old handbooks on the technique of physical experiments one can find recipes for mixtures of solvents which vitrify upon cooling. Shpol'skiĭ followed this path at first. In 1951 he and A. A. Il'ina published in JETP the article "Fluorescence of 3,4-Benzpyrene in Frozen Solutions." In this article it was shown that "when solutions of these hydrocarbons are frozen to the temperature of liquid air or liquid nitrogen the spectra of some of them (but not all) acquire a significantly more distinct structure." And very soon thereafter, a year later, in *Doklady of the Academy of Sciences of the USSR* a very small article by É. V. Shpol'skiĭ, A. A. Il'ina, and A. A. Klimov appeared, "Fluorescence Spectra of Coronene in Frozen Solutions." The year 1952 is recorded as the first date of discovery in the State Register of Discoveries.

Everything was unusual in this small article. Crystallizing solvents were used which formed a snow-like medium when cooled to 77 K (low-molecular n-paraffins). Instead of dozens of bands in the spectrum, about one hundred narrow lines were observed. No one had ever seen this type of spectra for these compounds. Thus, the report was received with interest, but also with surprise. I remember Shpol'skiĭ's reports at conferences on spectroscopy and luminescence. They listened to him, questioned him, made gestures of bewilderment. And Shpol'skiĭ and his associates presented the quasi-bright-line spectra of newer and newer compounds. Shpol'skiĭ himself called them quasi-bright-line spectra, but on the pages of periodicals appeared the terms "Shpol'skiĭ spectra," "the Shpol'skiĭ effect," the Shpol'skiĭ method," "Shpol'skiĭ multiplets," Shpol'skiĭ matrices." The spectra of different compounds were so individual that it was easy to differentiate spectrally isomers differing only in the position of the benzene ring. Widely varied hypotheses were expressed. Special studies showed that these were indeed molecular spectra that were observed in which the vibrational structure was resolved. This structure was complicated by the fact that the spectrograms clearly tracked the superposition of several identical spectra shifted slightly relative to each other; as a result, each band was split into a multiplet, depending on the solvent. Work on further study of the quasi-bright-line spectra required more modern spectral equipment than the several spectrographs and mercury lamps with which the laboratory was equipped. By agreement with P. L. Kapitsa (Shpol'skiĭ and Kapitsa families were friends) some of the studies at temperatures of 20 and 4 K were conducted at the Institute of Physics Problems. Shpol'skiĭ himself, naturally, could not spend a lot of time away from his own institute and assigned L. A. Klimova to work there for some time. And we graduate students remaining in the laboratory transported liquid nitrogen in ten-liter spherical containers on Tram No. 47 without having to change trams from the Institute of Physics Problems to our Institute on Pirogovskaya Street (earlier we had carried it from somewhere near Lefortovo).

In the meantime, the laboratory "attained manhood" both in a direct and indirect sense as graduate students arrived, among them R. N. Nurmukhametov and R. I. Personov, who later became well-known scientists. The laboratory gradually acquired more equipment and a possibility of acquiring more space appeared. In 1967, after much effort and approach to proper authorities Shpol'skiĭ, succeeded in creating a laboratory dedicated to the spectroscopy of complex organic compounds (it is true that it was in the third category of salary scales; for example, senior scientific personnel without an advanced degree received a salary of 88 rubles per month). The number of researchers interested in the nature of this effect and the possibilities of its application gradually increased. The list of studied substances expanded. Quasi-bright-line spectra were obtained for phtalocyanines, porphyrins, even chlorophyll and some polyenes. The Shpol'skiĭ effect immediately began to be used to develop very sensitive, initially qualitative and later quantitative methods of spectral-luminescent analysis in medicine, sanitation, geology, and other fields (the publications of T. A. Teplitskaya, A. Ya. Khesina *et al.*). The main "hunt" was for 3,4-benzpyrene, the strongest common carcinogenic active compound.

Shpol'skiĭ paid especially close attention to all research and supported it any way he could. Frequently some "guest" was working in the laboratory. They came from other cities (Shpol'skiĭ was not interested in official letters and assignment certificates), presented themselves, reported at a seminar, and if necessary, began to work and became "one of us." Some of "us" first appeared in Minsk (K. K. Solov'ev *et al.*), in Stavropol (V. A. Butlar *et al.*), Sverdlovsk, Chelyabinsk, Smolensk, Blagoveshchensk-na-Amure, and then in Wroclaw, Grenoble... . In Moscow, Shpol'skiĭ's spectra became a subject of serious interest at the L. Ya. Karpov Physico-Chemical Institute, at the All-Union Oncological Center, at the Geographical Department of Moscow State University, and at the Institute of Industrial Hygiene.

The number of compounds for which quasi-bright line spectra were observed was approaching 200 in 1961 when K. K. Rebane proposed that the Shpol'skiĭ effect should be seen as the optical analog of the Mössbauer effect (the article was published in 1963). In other words, the quasi-lines were to



É. V. Shpol'skiĭ at
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be seen as the result of optical phononless transitions in the studied molecules. But in this case each vibronic band should consist of a narrow phononless line and a phonon wing. Experimentally, this was clearly observed ten years later in 1971 by R. I. Personov *et al.* The vast body of experimental material accumulated by the end of the 1960s stimulated the theoretical research of I. S. Osad'ko, who proposed a semi-phenomenolgical theory with his own system of parameters, which made it possible to describe the basic features of the vibration structure of absorption and fluorescence spectra of specific compounds. In a parallel manner the Shpol'skiĭ method was used to study a wide range of rather fine effects associated with intermolecular interactions, the transfer of the energy of electron excitation, associations of molecules, etc.

When the "secret" of the Shpol'skiĭ spectra was revealed in general terms, and it was found that these spectra could serve as illustrations in textbooks and monographs on molecular spectroscopy, the issue of the nature of "traditional" structureless spectra of the solutions of a large number of organic compounds became especially urgent. This problem primarily challenged experimentalists. New opportunities to study complex molecules under various conditions appeared due to the rapid development of extremely delicate spectral methods based on the use of laser equipment. New prospects arose in electronic spectroscopy: fine selective spectroscopy. A large role in the development of selective spectroscopy of complex molecules in frozen solutions was played by the research of Shpol'skiĭ and R. I. Peronov. This research began in the early 1970s at the Academy of Sciences Institute of Spectroscopy. This research revealed new and broad opportunities to study complex molecules. The Shpol'skiĭ method, the results of the research of Shpol'skiĭ and his students and successors created the foundation for this new direction of research.

To complete the story of the last period of more than twenty years of Shpol'skiĭ's scientific career, one cannot help but talk about how he worked, directed, interacted with students. Shpol'skiĭ was not at all just an administrator, but knew how to solve informally the problems of directing a small but rather complex team. He was the boss, he taught us, sometimes lectured, always felt responsible for us, and always provided complete freedom of activity after the direction of research was determined. He was constantly interested in what we were reading, involved us in refereeing articles in the All-Union Institute of Scientific and Technical Information, provided reprints of articles. He attentively followed the course of experimental work and discussed intermediate results only with those coworkers who were carrying out his direct assignments. Shpol'skiĭ never put his own name as a co-author on a paper, the work for which had been carried out independently by his students. He read these papers, discussed them, but categorically rejected coauthorship. He always wrote survey articles himself. He taught us scientific "ethics." I recall when in completing a paper, several measurements had been made by a beginning trainee who naturally, wanted to be a coauthor very much. The measurements were made competently, but the young man could not yet recognize the essence of the work. I turned for advice to Shpol'skiĭ. He was very surprised: "He wants to be a coauthor? Tell him to write his own section of the article, and if he can't, thank him at the end for the measurements he made." The department placed very high requirements on graduate student examinations. Shpol'skiĭ paid no attention to instructions, and instead of one examination on the specialty of the graduate student (both experimentalists and theoreticians) examined them on the entire course of theoretical physics taken in parts. Shpol'skiĭ loved to organize seminars. At first, when there were few of us, the departmental scientific seminars occurred only now and then, but to make up for this we frequently went to the seminar at the All-Union Institute of Scientific and Technical Information. Later the departmental seminar became regular, as it is to this day.

Schpol'skiĭ willingly interacted with young people. He was at all departmental parties, and frequently invited us to his small apartment on Peschanaya Ulitsa, came to visit us, went to the theater with us. And he was already more than seventy years old! Participants in conferences on spectroscopy and luminescence in the 1950s to 1970s cannot help but recall Shpol'skiĭ, weighted down with cameras, always surrounded by young people. At the same time Shpol'skiĭ could be official and dry with people he didn't like. He was a very deep individual, and avoided people with shallow views and opinions. One could debate with Shpol'skiĭ, try to convince him of something, and he would not agree if he could see that the interlocutor really understood the subject of the debate. Shpol'skiĭ had a remarkable gift for selecting colleagues (he was especially attentive, not to say vigilant, about this). Even at the most complicated times decency and good will reigned among people in the department and the laboratory.

Shpol'skiĭ was a Teacher. In the last twenty years he almost never worked directly with students. But in his legacy to his successors (and this is no pompous phrase) he left a course in theoretical physics at pedagogical institutes. He was convinced that the future teacher of physics should complete his education with a rather profoundly study of the general laws of physics in all of their clarity and elegance, as well as the interrelations between them. At the beginning the course was brief, only lectures were given. But consider who gave these lectures! Shpol'skiĭ considered it his duty to attract well-known scientists to teach: in the 1950s V. L. Levich, E. M. Lifshits, B. T. Geĭlikman. Later, M. S. Rabinovich worked in the department for many years. Gradually, a full course in theoretical physics was created with a system of seminars, special courses, etc. Shpol'skiĭ himself lectured until 1956; as a rule, he gave a course in atomic physics (later it developed into a course on quantum mechanics). Later he occasionally gave separate, introductory, or overview lectures. I especially recall the latter. For Schpol'skiĭ each stage in the formation of quantum physics was an event that he had personally experienced, and this personal, almost enthusiastic attitude toward experimental effects, to the basic principles and postulates was clearly expressed in his lectures. It seemed that atoms, electrons, and nuclei were for him animated beings. Shpol'skiĭ was not simply an excellent lecturer, but a brilliant orator.

The second part of Shpol'skiĭ's pedagogical legacy is his two-volume textbook *Atomic Physics* (in Russian). The first one-volume edition appeared in 1944. He wrote it during the war. The next edition appeared rather soon, in 1948. In the preface to this edition he wrote: "The book has been subjected to a fundamental reworking. Without exaggeration it can be said that it has been written anew to a substantial degree." And further: "The exposition of several experiments now seems to me to be too elementary. In addition, it was necessary to elucidate further those issues which over the course of time have been advanced by the very development of science." The material in the book was divided into to volumes so that each of them represented a whole. Three years later (in 1951) the third edition appeared, and there was a great demand for the book. In twenty years (1944–1963) the first volume went through five editions, and almost every new edition contained new material. Thus, in already 1963 the textbook discussed the Vavilov–Cherenkov effect, quantum oscillators, lasers, and the Mössbauer effect. Gradually the book was translated into all European languages, Japanese, and Chinese. I present several excerpts from reviews of *Atomic Physics*.

1960, *Kerntechnik*, Professor Hanle: "The book can be seen as an example of the best didactics." 1969, *Nature*, Professor Hindmarsh, "It is frequently asked whether a comprehensive book of this type, devoted to a wide range of problems, can in fact be successful. The answer is the following: such books can exist, but they are rarely successful. This book, undoubtedly, is among the successful ones, and it is even more true that it can be compared with the finest examples of this genre in the area of atomic physics, particularly, with Max Born's *Atomic Physics*." And further, "Shpol'skiĭ presents himself to us an author who has delved deeply into the subject itself and the problems which confront teachers. The student is led in the book with great mastery through complex interrelations of theory and experiment." Finally, "...here we have an author with a complete knowledge of the intricacies of the physical thought involved in quantum theory."

On the initiative of the publisher, Nauka, after a ten-year interval, the two-volume textbook again appeared in 1974. I recall that at this time Shpol'skiĭ was already 80. The first volume was hardly any different than the previous edition. The second, which had not been published since 1951, was virtually rewritten. First, naturally, the second part of the previous edition, which was devoted to the nucleus and elementary particles, was completely eliminated. Second, Shpol'skiĭ felt it was necessary to give an idea of the most general formulation of the foundations of quantum mechanics. This is what he wrote in the preface "...Deductive exposition of the foundations of quantum mechanics is penetrating ever deeper into the textbook literature and into lectures (an example, is the *Feynman Lectures on Physics*). One can even predict that in the near future this scheme will supplant the currently accepted method of exposition, just as in this century in field theory the vector analysis method has supplanted the earlier accepted coordinate method. This situation, as well as the elegance and logical consistency of the abstract scheme, has prompted us to include in the book the third chapter, which is devoted to the relatively popular, although written at the required scientific-pedagogical level exposition of the scheme of quantum mechanics." Shpol'skiĭ wrote this new chapter, to which he deemed to be of such fundamental importance. But Shpol'skiĭ required a high level of professionalism not only from his students, but also, and primarily, of himself. He did not like how he had presented the material. He turned to A. I. Naumov to write the foundations of the theory of representations. So the high evaluation of the scientific-pedagogical level of the exposition of Chapter 3 was not written by Shpol'skiĭ about himself. Completing the brief history of this remarkable book (in one of the foreign editions it was called "the physics of explanation"), I would like to say that the last edition of the two-volume book was again released by Nauka, edited by A. I. Naumov almost ten years after Shpol'skiĭ's death. Here it is appropriate to note that Shpol'skiĭ knew its value, and he was always happy about the success of his books, and the high opinion of his scientific work. But he would not lift a finger to popularize *Atomic Physics*. It was enough that many foreign editions of his book had come out without his knowledge. Documents about the registration of his discovery began only after he was invited to attend the State Committee on Science and Technology and they proposed that this be done.

From where did Shpol'skiĭ draw the forces which helped him to the end of his days to retain his brilliant scientific and pedagogical intellect, his interest in life, and to support his love of physics? There is a definite answer to this: his beloved offspring, which he created, toward which he directed most of his efforts, and which infused strength in him his entire life: this journal, *Uspekhi Fizicheskikh Nauk*. Drafts were kept of a speech by Shpol'skiĭ in 1967 (apparently in connection with his 75th birthday). They must be presented:

"1. The particulars of my career are explained by the historical epoch and my individual tendencies.

2. My career with the beginning of the revolution. I worked at the country's first research institute myself only with science.

3. But very soon another side of my tendency appeared: the need to work not only for science, not only to acquire knowledge, but also to share it, to spread knowledge to the maximum number of people.

4. At the beginning of my career, stimuli were created to reveal these tendencies. The First World War, the intervention which followed it, and the blockade cut us off from the rest of the world. And great events occurred there at that time. In 1915 the general theory of relativity was published. In 1917, an earth-shaking event, the first observation of the deviation of light by a predicted amount as it passed the edge of the Sun. The theory of quanta achieved great successes (Sommerfeld quantization, the relativistic movement of the electron in the hydrogen atom). In England, the work of Acton, the discovery of isotopes of stable elements. The work of Rutherford, the discovery of the reaction $(n,\alpha)\rightarrow p$, transmutation of elements.

5. I plunged headlong into this tempestuous stream of earth-shaking discoveries and following my social and pedagogical tendencies, tried to introduce my friends and everyone who was interested [to these ideas]. I read an infinite amount of reports and lectures, wrote articles, translated articles and books.

6. And it was here that *Uspekhi Fizicheskikh Nauk* appeared on the scene, which I led from the second volume (and now the 93rd is appearing). I shall not describe the history of my involvement with this journal. I devoted myself to it with the greatest enthusiasm. I want to note the great deal of friendly help I received from Sergeĭ Ivanovich Vavilov, with whom I was friends from the age of 20 to his untimely death. Looking back on the almost fifty year history of *Upsekhi* I can without false modesty state the great value of this journal in the construction of Soviet science. In my speech at Moscow State University three years ago I compared it with a great all-union seminar, and this was actually so. Many generations of Soviet physicists have learned from *Uspekhi*. I myself have learned from it, and my heart skipped a beat as I read the articles of Schrödinger, Bohr, and others. Without such a journal in the history of science in Russia it would have been impossible to give the necessary scope of science."

It is difficult to add anything to that. Possibly one could only add that the journal became part not only of Russian, but also of world science, changing, in essence, to an international physics journal, which several years ago became the fourth most cited journal in the world. Shpol'skiĭ himself published more than 100 articles in *Uspekhi*: translations, abstracts, surveys.

I fell into the "orbit" of Shpol'skiĭ when the journal had been existence for more than 30 years. His work was clearly laid out. Shpol'skiĭ was usually at *Uspekhi* on Wednesdays, sometimes the editors came to the department. I recall the energetic, elegant V. A. Katanyan, the taciturn S. G. Suvorov. Then the lively, impetuous V. A. Ugarov appeared, and the always cordial L. I. Kopeĭkina. Although all the members of the department, the editors of *Uspekhi*, the editors of the abstract journal knew each other very well, and frequently talked to each other, forming a thick "condensate" around Shpol'skiĭ, I know little about the work of Shpol'skiĭ the editor. I know that he always read or carefully examined each manuscript. I know that he literally suffered when highly specialized articles began to appear more and more often in the journal. In my opinion, he even dreamed that someone would write a popular guide on modern physics for physicists, and frequently bitterly lamented that as branching occurred and science became narrowly specialized, the general cultural level of physicists fell. Shpol'skiĭ understood the term "good physicist" to require the inclusion of the term "cultured person." He himself certainly was among the widely educated people. He knew and loved music, art, and classical literature. One day in the large council of the institute he all but failed a candidate for the post of professor in the Russian Literature department: He carefully listened to the flattering characteristics ascribed by the candidate for the post, presented as a well-known specialist on the work of Lev Tolstoĭ, asked to say a word and announced that he knew the literature on Tolstoĭ well, and that the candidate for the post was a "complete unknown."

In the drawer of a desk in the department was an old thick notebook, and the first notes in it were made by Shpol'skiĭ, apparently in the mid 1940s. The last were written in 1969. Basically these were references to articles, recipes for developers, brief excerpts from individual articles. And at the very beginning of the notebook, there were several pages of text entitled "The Cultural Role of Physics." This, apparently, was Shpol'skiĭ's brief notes for a speech (where, when, for whom, I do not know). I present the key statements contained in this text:

"1. The level of development of physics determines the entire appearance of current culture.

2. Over time physics is inevitably introduced into other areas of natural science.

3. Physics is the pledge of the development of the future culture.

4. The development of physics has a decisive effect on the development of spiritual culture.

5. Physics should play a primary role in the education system.

6. The educational value of physics. Without a knowledge of physics it is impossible to understand current culture. Physics unites the inductive method with the deductive method. It trains one to notice barely noticeable but important facts. It develops logical capabilities and schools one in accuracy."

Below follows a citation from the works of N. A. Umov, which was presented above as an epigraph.

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Translated by C. Gallant